THE ENGINEERING RECORD
PUBLISHED WEEKLY BY THE
McGraw Publishing Company

James H. McGraw, Pres.
J. M. Wakeman, 1st Vice-Pres.
A. E. Clifford, 2d Vice-Pres.
C. E. Whittlesey, Sec. and Treas.

John M. Goodell, Editor.

MAIN OFFICES:
239 WEST 39TH STREET, NEW YORK.
BRANCH OFFICES:
CHICAGO: Old Colony Building.
PHILADELPHIA: Real Estate Trust Building.
CLEVELAND: Schofield Building.
LONDON OFFICE: Hastings House, Norfolk St., Strand.

SUBSCRIPTION RATES.
United States, Cuba and Mexico..........$3.00 a year
Canada ....$4.50 a year
Foreign subscription.....................$6.00 a year
25 shillings. 25 marks. 31 francs.
Foreign subscriptions may be sent to our London office.

NOTICE TO ADVERTISERS.

Changes in advertisements intended for a particular issue should reach the office of THE ENGINEERING RECORD on Friday of the previous week. New advertisements can be received up to noon of Wednesday of the week of issue.

NOTICE TO SUBSCRIBERS.

REMITTANCES.—Remittances should be made by check, New York draft, or money order, in favor of THE ENGINEERING RECORD.

CHANGE OF ADDRESS.—The old address should be given as well as the new, and notice should be received a week in advance of the desired change.

BACK COPIES.—No copies of issues prior to January, 1907, are kept on sale, except in bound volumes.

DATE ON WRAPPER indicates the month at the end of which subscription expires. The sending of remittances for renewal prior to that date will be much appreciated by the publishers.

CLUB RATE.—In acknowledgment of assistance rendered by subscribers in the securing of new orders, a club rate of $2.50 per annum is quoted. This rates applies to subscriptions in clubs of two or more, at least half of the names in the club to be those of new subscribers.

Entered at the New York Post-Office as Second Class mail matter.

Copyright, 1908, by the McGraw Publishing Co.

The circulation of THE ENGINEERING RECORD for 1907 was 763,000 copies, an average of 14,673 copies per week.

Of this issue 16,000 copies are printed.

TABLE OF LEADING ARTICLES.

Elastic Limit and Yield Point.................... 569
Refuse Destruction in Seattle.................... 569
A British View of American Technical Education... 570
Power from the Coal Fields....................... 571
Railroad Grading by Hydraulic Methods on the Chicago, Milwaukee & St. Paul Railway (Illustrated) 572
The Bostwick-Braun Building, Toledo, Ohio (Illustrated) 575
Experiments with Dust Preventives on a Road at Wayland, Mass......... 578
An Investigation of Cylinder Oils................ 580
The Erection of the Towanda Bridge (Illustrated).. 581
A 60-Ton Refuse Destructor in Seattle, Wash. (Illustrated) 583
The Phelan Building Floor Construction (Illustrated). 585
Time Penalties on Government Contracts.......... 587
A Working Method for Masonry Arch Design (Illustrated) 588
Deep Underpinning for a Brick Factory Building (Illustrated) 589
Large Gas Engines for Steel Works at Gary (Illustrated) 590
An Unusual Concrete Chimney (Illustrated)........ 593
Cutting a Subway Through Masonry Bridge Piers (Illustrated) 594
The Dye House of the Washington Mills, Lawrence, Mass. (Illustrated)......... 595
A Concrete-Block Track for Highways (Illustrated).. 596
Septic Tank Patents.............................. 596

Elastic Limit and Yield Point.

The elastic limit of structural materials was one of the earliest quantities to be determined by careful experiment. It was regarded as a point of much importance in the distortion of a material; so much so in fact that forty or fifty years ago much effort and nicety of definition was expended in attempting to describe it in such a way that there could be no doubt as to its real character and meaning. In all the earlier laboratory and structural experience, however, the elastic limit was regarded as either of analytic or refined physical interest than of much real significance of a structural kind. The reason for this is rather obvious enough, for prior to the execution of structural operations of magnitude the elastic limit was of interest almost wholly as indicating the extent of application of the mathematical theory of elasticity to solid bodies and to a number of refined physical operations of much real importance relating to elastic vibrations and various wave motions involved in the theories of light, sound and other fields of physical research. Indeed, all the older works on elasticity in solid bodies, like those of Lamé, Rankine and many others, give the most conclusive evidence of these facts, and no modern treatises on the elasticity and resistance of materials can be considered even approximately complete without the elaboration of the formulas first set forth in those early works.

The development of structural operations, especially in the fields of iron and steel, has brought about a fundamental change in all these things. It is still necessary and always will be to establish formulas required in the operations of design on the basis of the purely elastic properties of materials and then introduce by means of full-size tests of members such empirical coefficients, or other numerical quantities as may be needed to adapt those formulas to the conditions existing between the elastic limit and ultimate resistance or ultimate carrying capacity. The phenomenon of actual collapse or failure of either test specimens, or of full-size tension or compression members is such a marked and impressive incident in experimental work that it has attracted to itself far more attention than it deserves. Obviously, when failure of a member takes place either in tension or compression it may be broadly stated that the structure in which it is found will almost inevitably be wrecked, hence, it has come to be tacitly, if not explicitly reasoned, the ultimate carrying capacities of members must necessarily be determined and the allowed stresses in them should be fixed in regard to their ultimate resistance. All this seems plausible and it is not surprising that engineers have accepted the situation thus set forth as controlling in their designs.

Engineering experience of the last twenty-five or thirty years has, however, shown that the ultimate carrying capacity is not by any means the only controlling consideration in designing structures or structural members, as important as that particular quantity may be. It is usually the practice to take the working resistance in tension in ordinary steel eye-bars at perhaps one-fourth of their ultimate resistance, thus making the so-called "safety factor" four, although that term is one which should be abolished from use. As a matter of fact, if by any exigency that eye-bar should be subjected to three-fourths of its ultimate resistance, it would unquestionably have to be displaced by a new one; and the same observation would hold for even a less intensity of stress. Similarly, in spite of the number of tests of full-size columns that have been made in the past, the same misleading "safety factor" has been carried over into the design of compression members. No such so-called "safety factor" exists in these members. It is probable that in most cases where the working load is supposed to be one-fourth the ultimate capacity, it really lies between one-half and one-third.

It is well known that while there is little or no evidence of fatigue of iron or steel below the elastic limit, it begins to manifest itself immediately above that point. Furthermore, the rapid distortion which begins to take place at the yield point or stretch limit is sufficient to render any structural member essentially unfit for further duty; indeed, it is highly probable that the yield point marks the ultimate carrying capacity of all columns ordinarily used in structures. It is clear therefore that the elastic limit and the yield point are the crucially important stress determinations in reference to which permissible loads are to be established, or in reference to which structural designs are to be controlled. While it is obviously important as well as interesting to know what the ultimate carrying capacity of any structural member whatever may be, the greatest permissible stresses and the corresponding greatest permissible loads of the structure are to be governed by the elastic limit and the yield point, and by those quantities only. In fact, it may be stated without much exaggeration and probably without much danger of challenge at the present time, that the elastic limits of full-size tension members and full-size compression members will hereafter be the controlling quantities in design. There are unfortunately practically no column tests showing the elastic limits of such members as wholes or how much such members will hold above those elastic limits. It is obvious that the elastic limit of a built column as a member may be substantially different from the elastic limit of the material of which it is constructed and as determined by small specimens. It may be stated confidently that if a structural member is never loaded more than one-half to two-thirds of its elastic limit, it will never fail; but if this permissible loading is fixed at some fraction of the ultimate resistance of the material of which it is built, as determined in the usual manner by small specimens, there is no assurance of the degree of safety obtained.

Refuse Destruction in Seattle.

Such a surprisingly small amount of data regarding the character of the municipal wastes produced in this country and the proper methods of disposing of these wastes is available that the results of the operation of a destructor recently installed in Seattle will probably be of some value. The details of the construction and operation of this destructor, together with a brief outline of the character of the materials delivered to it, are printed elsewhere in this issue of The Engineering Record. The various classes of refuse in the residential and the business districts are collected by private scavengers, each of whom owns from one to several teams and wagons. The premises served by these men pay a fixed charge for the collection, based largely on the amount of refuse produced. The materials collected were formerly all hauled to a public dump on land submerged by the tide about one mile south of the central district. The haul to this dump from certain parts of the city is of such length that a large portion of the outlying residential districts have no refuse-collection service, while many residents in other sections will not pay the private scavengers. In fact, an investigation of the conditions existing prior to the construction of the destructor indicated that although close to 300 tons of refuse were produced each day only about 200 tons were collected, the remainder being incinerated or disposed of in some other manner by the producers. The private system of waste collection, although quite generally considered to be more expensive and in some ways less satisfactory than a municipal organization capable of producing the same results, is almost universal in the large cities on the Pacific Coast. The local conditions in Seattle will not permit an immediate change to a public system of waste collection, even though it will be feasible to make such a change later.

Not only is the public dump too far from certain parts of the city, but it is also particularly offensive. Since more satisfactory places of deposit could not be obtained, some means of incineration or reduction had to be installed to eliminate the nuisance caused by the dump. Before a decision regarding the type of disposal plant to be adopted was reached, Mr. R. H. Thomson, city engineer of Seattle, made an extended tour through this country and Europe to study various methods of disposal. As a result of this investigation, he recommended the erection of a destructor in which the mixed municipal wastes collected could be incinerated without the addition of other fuel. On account of the fact that any destructor selected would have to meet unknown requirements, he advocated that one with a daily capacity of 60 tons, or about one-sixth of the total refuse produced, should first be built, and that this destructor should be operated for a sufficient period to determine the feasibility of burning the mixed refuse delivered to it without additional fuel. Meanwhile, the modifications of design necessary to obtain the most satisfactory and economical methods of storing and firing the refuse could also be ascertained and applied in future plants. These recommendations have been carried out. The experience obtained in the operation of the first destructor will govern the design of several proposed additional destructors of about the same capacity as the first, with such changes in construction and arrangement as appear desirable. These additional destructors, which will be located at various sites selected to reduce the average haul to a minimum, will provide for the incineration of all the refuse produced.

At the time the original investigation was made Mr. Thomson was of the opinion that no financial return could be obtained from garbage-reduction works operated in Seattle, even though a profit may have been made from such works in other cities. Besides, the necessary separation and double collection of the mixed refuse at present delivered unsorted would involve a greater expense than if all the materials were destroyed together. Recent developments in the reduction of garbage as a strictly sanitary provision, and not primarily to obtain a profit from by-products, may, however, ultimately render desirable the operation of garbage-reduction works in connection with the several proposed destructors.

The new destructor in Seattle is built according to the best English practice that has been developed in connection with the type adopted. From the results obtained during the first three months of operation, it is believed that the destructor is well adapted to the service for which it was built. Local conditions, nevertheless, will doubtless justify some slight changes in the arrangement and construction, as are generally required in plants of such character built to meet conditions which are impossible of analysis previous to actual operation. The character of the mixed wastes delivered to the destructor and the waste conditions in Seattle being different from those in other cities where destructors have been installed, as is to be expected, will have a marked influence on the nature of the changes made. The volume of the refuse produced in the city also being so greatly in excess of the capacity of the destructor, it will be possible to regulate somewhat the percentage of different wastes incinerated, so a normal average for the entire city may be obtained during the period preceding the design of the additional destructors.

The experience already obtained has fully established that the mixed refuse collected can be cremated by the heat capable of being produced from it, and has also demonstrated the absence of nuisance from the destructor. After the latter has been in service long enough under the continued present careful supervision to determine any needed changes in the methods of storing and firing the refuse, and to afford an opportunity to educate the firemen, even the present excellent results from a sanitary standpoint are likely to be improved. The cost of handling and incineration, while at present not excessive, can likewise be much reduced at the same time. Although the character of the refuse collected in Seattle, as indicated by the preliminary data secured, differs to a certain extent from that of the wastes produced in most other cities in this country, the results of the operation of the destructor will add to the scanty information at present available regarding the incineration of mixed refuse without auxiliary fuel. Since these results will, of course, be of special value in determining the design of future disposal plants in Seattle, the erection of a destructor of small capacity, built according to modern practice as adapted to conditions in other cities, to determine the modifications of design made necessary by local circumstances, rather than the initial construction of a single large incinerator, is commendable.

A British View of American Technical Education.

During the recent visit of Sir William H. Preece to this country, he investigated some of our American engineering schools, and at a recent meeting of the Royal Society of Art gave an appreciative criticism of some of our methods of instruction. It might be stated at the outset that Sir William has the right to speak authoritatively on the subject since he has been associated with two important educational innovations in England. Years ago he organized a system of instruction in telegraphy which was remarkably successful. It was based on his belief that technical education is more the result of self-acquisition than of professional instruction, and that the true secret of success is to place within easy access of the student every possible means of enabling him to acquire facts for himself. Accordingly in the system of instruction which he developed for the higher branches of the English telegraph service, he used the same apparatus that regular operators employ and put the pupils through the various processes of construction and maintenance they would have to supervise or exercise in their future work. The success of this method of instruction convinced him years ago that it was important for anyone learning a technical subject to be instructed with the tools and processes actually employed in the practical applications of the subject. It is not surprising, therefore, that in his address, he lays stress on the remarkable extent to which instruction in American technical schools is carried out along these lines. Another important contribution by Sir William to the cause of technical education was the adoption by the Institution of Civil Engineers of qualifying examinations for admission and promotion in its grades. In securing the adoption of these examinations he was associated with Sir John Wolfe Barry and Sir Wm. H. White, and the result of the system has been the material improvement of the character of technical education required in Great Britian for actual professional work.

Not only Sir William but also some of the engineers who discussed the paper agreed that the American technical school has an advantage over those of England in the fitness of the young men for their work. Sir William made the following statements concerning the students in the lowest classes at the Carnegie Institute in Pittsburg: "The type of student in Pittsburg is quite equal to that of our provincial university. Nothing surprised me more than the character of the apprentices and journeymen who study and practice with all that wonderful energy that is such a marked feature in American life. This imbibed energy is not a question of race, but one of climate, for it affects all those who go there, whatever their nationality. It is as evident in the teacher as in the pupil." Dr. Mullineux Walmsley expressed this thought as follows: "The cause of the present state of affairs (in England) is the indifference of the average British parents to the needs and possibilities of education. Parents will not send their sons for a four-year course when they can get a three or two-year course elsewhere, entirely because of the indifference to education which exists." Mr. Francis Owen stated that "the cause of the backwardness of education (in England) was that there was no desire on the part of the lower classes for it. One of the reasons for that condition of things was that the teachers had been forced into a groove and were obliged to follow the code without any freedom being allowed. The inevitable consequence was that the teacher drummed the facts relating to the syllabus into the heads of the children with the result that all spontaneous impulse in their minds was stifled." The enthusiasm for technical education shown by the young men in America is only equalled, according to Sir William, by the extent of the help afforded by manufacturers to technical colleges. In no American shop is it customary to enforce the premium plan, long in force in England, under which a young man must pay the owner of a shop or the head of a professional firm a considerable sum in order to enter his office or works and learn the trade or profession. American employers recognize the advantage of technical attainments, encourage research, equip their own laboratories handsomely, and support both the college and the university by financial help and the gift of machinery. Sir William was particularly struck by the lavish supply of apparatus in every technical school, which made the equipments of British schools simply insignificant.

One feature of our system of education which impressed Sir William, as many previous observers, is the fact that although there is no national control of educational affairs, each State looking after the subject according to its own ideas, the tendency is along fairly uniform lines of advance everywhere. Sir William points out that it is probably by intuition rather than by rule that a course of development has been followed, and by the financial aid of men who have amassed fortunes, those responsible for our methods of instruction have been able to coordinate together all lines of education, primary, secondary, advanced, technical and academic, so that they work together toward a final goal of culture and skill. It is his opinion that each class is directed in the proper channel to reach that special state of cultivation and skill best suited for its own wants and ends. One great help in educational matters, he believes, will be the pension system of the Carnegie Foundation for the Advancement of Teaching, which places American professors in the same independent position as civil and military employees of the British government. He also mentions with approval the fact that American instructors are generally practical men and most engineering colleges require their professors to keep in touch with experience. "The academical professor who has lived a secluded life in some university town," Sir William stated, "is the worst teacher on earth, his knowledge of life is limited, but his valuation of his own qualification is excessive. The knowledge he has imparted has often to be unlearned."

The courses of instruction in the Carnegie Institute at Pittsburg are particularly approved by Sir William on account of their fitness to the local economic and industrial needs of that city. He has always considered a technical education to be that form of teaching which trains the brain to assist the hands. Every industry is based on natural facts, and the most successful workman is he who is able to apply the facts of nature and the dictates of common sense, which is science, to produce the greatest economical effects from the least expenditure of energy. Hence technical education means an economical advance upon general education, he points out, and is supplementary to ordinary public school tuition. The large library, the small class-rooms which bring teacher and student into close contact, and the small number of pupils per teacher were features of the Carnegie Institute system which appealed most strongly to Sir William and convinced him that the instruction was likely to be of the highest type of its kind, in view of the enthusiasm of both pupils and teachers. He mentions one rather surprising condition of skilled labor in the United States, which is that the proportion of skilled foreign labor in 1902 in New York was 70 per cent., 60 per cent. in Chicago and 75 per cent. in Brooklyn. It is hoped that such institutions as the Pittsburg technical schools will gradually reduce this remarkable proportion of skilled workmen of foreign birth. These observations by the British engineer are emphasized by some criticisms he made concerning the general educational system of his own country. It is his opinion that science as a brain trainer is not encouraged enough, and that there are too many academic traditions. Furthermore English technical schools are not sufficiently supported by manufacturers, he believes, and trained graduates of such schools are not welcomed in English shops. What technical education is given in England is not carried far enough, in his opinion, and there should be an additional year for instruction along some specialty. These recommendations, it will be seen, are practically an endorsement of the characteristic features of American technical education and American public opinion regarding it.

Power from the Coal Fields.

The steady growth of big power transmission networks utilizing the available water powers of a large territory brings again to mind the tremendous possibilities of utilizing low grade coal for similar distributions. The suggestion has been made times without number and actual plans for such developments have been repeatedly formulated, quite uniformly without result. It is high time for somebody to make good the bluff. At present there are so few plants actually engaged in power transmission from fuel supply that one can count them on his fingers. Yet looking at the matter in the larger aspect it is perfectly clear upon a little reflection that the proposition has been practically demonstrated to be a paying one by experience gained upon a large scale. If one looks over the field of central station development he finds a number of colossal plants in the large cities which have deliberately pursued the policy of taking over by purchase or consolidation all the small suburban plants within reach and replacing them by power transmitted from a great central plant even over distances of twenty miles or more. Granting that this change of method may now and then be overdone for the sake of uniformity of policy, it still has been abundantly demonstrated that the saving in cost of production by generating all the power on an immense scale at some favorable point is more than enough to recoup the losses in transmission.

This being so, it is easy to see that if the power generation could be done in a region of exceptionally cheap fuel the saving as against localized plants in places where fuel is high would be still more considerable, while the added expense of transmission over the greater distances likely to be required would be relatively small. Most of the central station long-range distribution referred to is done at voltages not exceeding 10,000 or 11,000, while, by merely raising these figures to 30,000 or more, the economical radius of distribution could be more than doubled at very modest increased cost. In other words, if it pays to distribute power from a central plant as against local production at, say, 10,000 volts, one could afford at 30,000 to 50,000 volts a pretty long transmission for the sake of cheap fuel, fuel in a well ordered large plant being the chief item of expense. The central stations have therefore already shown the way and demonstrated the economy of great distributing networks. It only remains now to put the chief generating plant at the fuel supply, transmitting power instead of hauling coal. The greatest gain can, of course, be made in the utilization of cheap coals—cheap because of low grade and difficult or unprofitable to transport. This is true of a good deal of the meaner coal of the Middle West, to say nothing of the lignite still further inland. Power generated from such fuel sources can be obtained at the busbars quite as cheaply as it can be generated at the ordinary hydroelectric plant which is considered a first-class investment. In exceptional cases only is the water power the cheaper by any considerable amount, when one considers cheap coal at the mouth of the mine.

What then is the cause of the hesitancy of capital to embark on such enterprises? It is not easy to say. Perhaps it comes in part from mere natural conservatism, perhaps from bitter experience of the early days of electric lighting, and perhaps in part from a vague and baseless feeling that enormous electrical improvements are impending. So they may be in certain lines, but they cannot materially effect the economy of the generating plant, since the generators already are within 5 per cent. of the theoretical efficiency of conversion of work in electrical power. The prime mover is more likely to be improved, but if the transmission from coal demonstrably is profitable with our present prime movers the case will be helped and not hurt by improvement. The ideal efficiency would, of course, be most nearly reached by gas engines, which are fast coming to the front, but steam turbines in, say, 10,000-kw units can make a good showing right now. The best organization of the fuel transmission plant would be that of a great network fed from plants at two or three points, perhaps of 100,000 kw each. A transmission and distribution network at 50,000 volts can cover economically a vast territory, and this pressure can even now be safely raised by a third or a half. The system would then be ready to furnish electrical energy, preferably at wholesale only, over a region of 10,000 or 15,000 square miles at prices that would be attractive to local users. The main point is that this is merely a logical extension of the long range distribution work already successfully carried out by a number of central stations in this country. In England steps have already been taken in the inauguration of big power systems, but the work has not been rapidly pushed. It is high time that American enterprise bestirred itself in this line. In hydroelectric plants the Pacific Coast leads the world. The Middle West has few water powers, but plenty of coal and abundant initiative, and should soon be heard from in power transmission from fuel.

Notes and Comments.

PLANS FOR A MUNICIPAL OFFICE BUILDING for the City of Greater New York, prepared by McKim, Mead & White, have been recommended by a board of architects appointed by Mayor McClellan to judge a number of designs submitted in competition. The new building is to be twenty-three stories in height and the design provides a floor plan making most of the offices outside, without an interior court. A large saving in rentals will be obtained by housing all of the city government offices in this building, while the latter will provide space for much future growth of the municipal departments. The city is fortunate to have the new structure in charge of an organization like that of the successful architects.

THE UNION ELEVATED RAILROAD LOOP in Chicago has again been brought into consideration for improvements by a report which Mr. George Weston has submitted by request to the committee on local transportation of the Chicago city council. The capacity of this loop, which serves all four of the elevated railroads in the city, has for years been entirely inadequate to handle the traffic tributary to it. Various local conditions have been considered, however, to preclude betterments or changes in the structure that would improve the down-town terminal facilities of the four lines. In the comprehensive report submitted by Mr. Weston the estimate is made that the capacity of the loop may be increased 43 per cent. by the following changes: Through routing of trains; extension and rearrangement of station platforms; development of stub terminals and universal transfers. These changes will render it possible to handle comfortably 65,880 passengers an hour on the loop, as compared with the present capacity of 40,800 in the same time that is obtained by the utmost crowding. The report indicates that the improvements suggested will be made to the large advantage of the companies and that no serious physical difficulties are to be overcome in executing these changes. The restriction of the central business district by the loop and the evident limitation of the ultimate development of the latter render the structure at best a makeshift which must soon either be greatly enlarged or replaced by subways.

HYDRAULIC SLUICING METHODS have rarely been employed in railroad grading, although so long used extensively in placer mining and more recently in the construction of numerous earth-fill dams. In fact, the excavation in a section of heavy grading on the Pacific Coast extension of the Chicago, Milwaukee & St. Paul R. R. that is being moved hydraulically probably involves the largest total quantities of materials that have been handled in this manner in railroad construction. A full description of the conditions surrounding this work and of the plant installed to conduct it appears elsewhere in this issue of The Engineering Record. The materials to be moved are of such character that they can be loosened from the face of the cuts by streams under moderate pressures and thence readily delivered to place in flumes by the water. A large quantity of water available under a fairly high head also renders possible the delivery of the sluicing streams most economically. It is evident from the results obtained in the prosecution of the work under these favorable conditions that the materials are being moved much more rapidly than they could be by any other means involving a similar outlay for plant. At the same time, the total cost per cubic yard of handling the materials is unquestionably lower than it would be with ordinary mechanical equipment. While the conditions presented in this particular work are especially favorable to moving the materials rapidly and economically by hydraulic methods, experience on various other projects where these methods have been used shows that even materials which require occasional light blasting can thus be handled very cheaply. It has also been found that the water necessary can be pumped against fairly high heads and still permit remarkably low unit costs to be secured. Furthermore, in several instances where only a comparatively small amount of water was available this supply has been used repeatedly. Another feature that has been brought out particularly in the operations on the section of the Chicago, Milwaukee & St. Paul R. R. extension is that the cuts could be made at a very high rate if the materials from them might be wasted. The possibility of adopting hydraulic methods to various soil and water-supply conditions is evident from the results obtained in this and other instances. These methods can also be employed to particular advantage when used in connection with work so isolated that the large amount of heavy, bulky mechanical plant required in the prosecution of ordinary methods is brought to the site with difficulty.

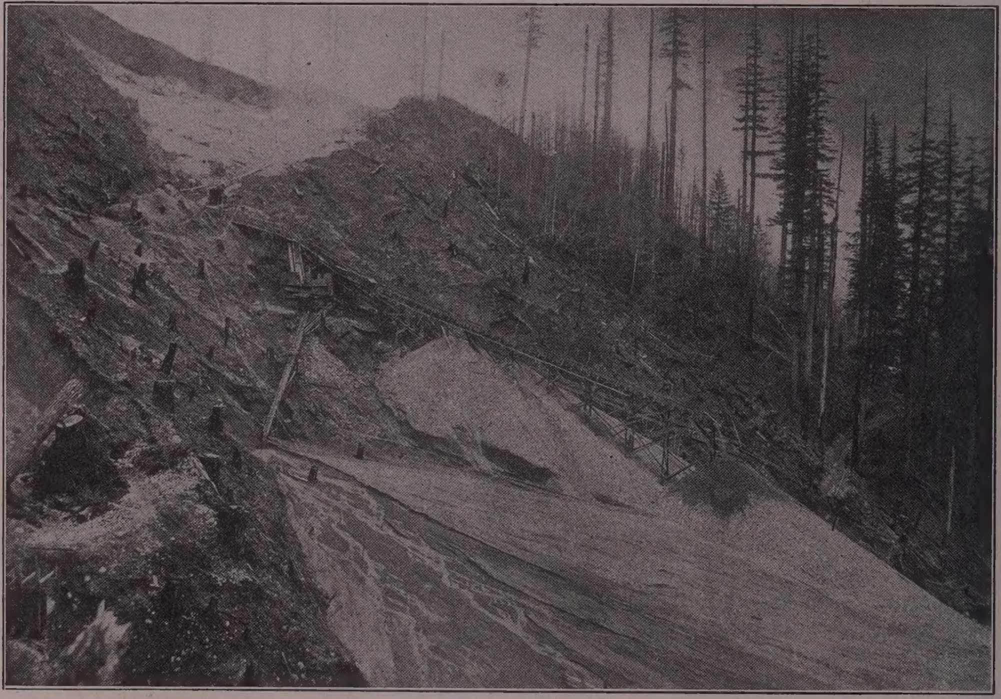
RAILROAD GRADING BY HYDRAULIC METHODS ON THE CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.

A section of grading work involving 1,000,000 cu. yd. of excavation in about half a mile, is being done by hydraulic mining and sluicing methods on the Pacific Coast extension of the Chicago, Milwaukee & St. Paul Railroad, at a point 14 miles west of the summit of the Cascade Mountains in the State of Washington. Although the western slope of these mountains is very abrupt, a location has been obtained for the new line that enables the establishment of 1.75 per cent. as a maximum rate of grade and 10 degrees as the maximum rate of curvature on the ascent to the summit from the west. A large amount of heavy grading is required in places to obtain the low established maximum rate of grade through the steep and broken country crossed. At the same time, the total amount of grading necessary is comparatively not great, if the particularly rugged character of the western slope of the mountains is considered. Most of the materials encountered are also of such character that they can be moved readily.

The new line follows up the Cedar River valley for some distance after leaving Puget Sound, and then passes over a divide into the watershed of the south fork of the Snoqualmie River. It ascends the valley of this fork to the head waters of the latter, where it reaches the Snoqualmie Pass, in which the summit of the main range of the mountains is crossed. Easy grades are obtained on all that part of the line in the Cedar River valley, as the climb to the summit starts a short distance after the valley is left to enter the one of the south fork of the Snoqualmie River. Owing to the complete isolation from railroad facilities of most of the portion of the line on which the main part of the ascent is made, and to the difficulties presented to the construction and maintenance of wagon roads, the grading work is largely being done with comparatively little mechanical plant. Dump cars, operated on short stretches of track, are used in making some of the heavier cuts and fills, but a large part of the grading in the vicinity consists in side-casting to form bench cuts for a track on the steep hillsides.

The heavy section of grading on which the hydraulic methods are being utilized embraces two embankments and two large cuts; one of the embankments it is estimated will require 700,000 cu. yd. of material in a distance of approximately 800 ft. on the center line of the track; a cut to the west of this fill from which 350,000 cu. yd. of material must be moved in 800 ft. on the line; a second cut to the east of the large embankment, which cut necessitates the removal of 450,000 cu. yd. of material in a distance of 700 ft. on the center line, and a smaller embankment to the east of this latter cut in which 100,000 cu. yd. will be placed to bring about 400 ft. of track to grade. The total of 800,000 cu. yd. of excavation required in the two cuts will all be utilized in the two embankments. The larger of these embankments will have an extreme width of something over 700 ft. at the base, while the track carried by it will be about 280 ft. above the extreme toe of the outer slope. The cut to the west will have a maximum depth of 225 ft., while the maximum depth of the one to the east is to be 240 ft. Any ordinary method of handling these large quantities of materials in a reasonable time would have required an extensive plant, even if previous methods could have been used. On the other hand, the hydraulic method, which was adopted largely on that account, has proven particularly well adapted to the conditions.

The water for sluicing purposes is diverted from the south fork of the river, 5,500 ft. upstream from the gulch across which the large embankment is being made. A flume carries the water down stream from this diversion to a penstock for a 38-in. wood-stave pressure-pipe line at the edge of the gulch, this penstock being between the river and the railroad location. The head of the pipe is about 200 ft. below the grade of the track, and from this elevation the pipe extends down the steep side of the gulch to a pumping plant on the bank of the river. Part of the water delivered to the pumping plant by the pressure pipe is utilized as power to drive impulse wheels direct-connected to a turbine pump, while the balance passes to the suction of the pump under a head of nearly 400 ft. The pump discharges into a 24-in. riveted-steel pipe line 1,400 ft. in length, which extends up the steep side of the gulch, parallel to the wood-stave line to above the level of the track grade. At this level branches are carried from the main pipe to the pits where the hydraulic mining is in progress.



Cut and Embankment on West Side of Deep Gulch.

The diversion from the river is made by means of a rock-filled timber-crib dam built across a narrow rock gorge. The flume, which is V-shaped in cross-section, starts from a headworks in one end of this dam and is built on a uniform grade of 0.3 per cent. This grade gives the flume a theoretical carrying capacity of 100 cu. ft. per second when running full. The V-shaped cross-section was adopted instead of the usual square or rectangular section for three principal reasons: First, a maximum hydraulic mean radius, and, consequently, a maximum capacity could be obtained with a flume of this type for any certain amount of lumber. Then, a V-shaped flume could be built with less difficulty than any other type, and could be fit to sharp curves quite easily. Besides, it could be made tight more readily than any other type.

The details of the construction of the flume are shown in one of the accompanying illustrations, and a view of a section of the completed flume in a second illustration. The sides are built of two thicknesses of 1-in. plank, varying from 6 in. to 14 in. in width. The planks were cut in 12, 16, 20 and 24-ft. lengths so they could be laid with broken joints. The longitudinal joints in the lining were also laid to break joints with those in the outer layer of plank. The box of the flume is carried by frames, spaced 4 ft. apart on centers. These frames each consists of a 4 x 4-in. timber under each side, braced up on a hewn sill, about 6 x 6-in. by 8 ft. Each 100 linear feet of the flume required 1,854 ft., board measure, of 1-in. plank; 25 pieces of 4 x 4-in. timber, 10 ft. long—to make fifty 4 x 4-in. pieces, 5 ft. long; 8½ pieces of 2 x 4-in. timber, 14 ft. long—to make fifty 2 x 4-in. pieces, and twenty-five hewn sills, 8 ft. long. The sides and frame are of fir cut at a mill in the adjacent woods, and the sills were hewn from celar trees cut near at hand.

For 3,500 ft. from the dam the flume follows the contours of the ground, the hewn sills being laid directly on the latter. Several small cuts in rock and a few short trestles had to be built to obtain the established grade in this distance. At the end of this section the sides of the hills at the elevation on which the flume had to be maintained were so steep that it was more economical to carry the flume for 950 ft. on a continuous timber trestle, varying in height from 10 to 50 ft. Beyond the downstream end of this trestle the flume is again directly on the ground to the penstock of the wood-stave pressure pipe. The river has a fall of over 400 ft. between the diversion dam and the penstock of the pressure pipe, which is thus developed by the construction of the flume.

TABLE 1.—SPACING OF ½-IN. ROUND MEDIUM STEEL BANDS FOR 38-IN. STAVE PIPE.

Spacing c to c of bands, inches.	Permissible head, feet.	Spacing c to c of bands, inches.	Permissible head, feet.
12	39.8	3	159.2
11	43.3	2⅞	166.6
10	47.7	2¾	173.6
9	53.0	2⅝	182.0
8	59.7	2½	191.0
7	68.3	2⅜	201.0
6½	73.5	2¼	212.2
6	79.7	2⅛	224.5
5½	87.0	2	238.5
5	95.5	1⅞	254.5
4¾	100.0	1¾	273.0
4½	106.0	1⅝	294.0
4¼	112.0	1½	318.0
4	119.5	1⅜	347.0
3¾	127.2	1¼	382.0
3½	136.5	1⅛	425.0
3¼	147.0	1	....

The wood-stave pressure pipe line leading from the end of the flume to the pumping plant is 800 ft. long and has a uniform diameter of 38 in. It follows the undulations of the steep side of the gulch and is anchored at different points by wire cables attached to lugs bolted to the staves. The pipe is designed for a maximum head of 400 ft., which, with one exception, is believed to be the highest head for which wood-stave pipe has been used. The staves of this pipe were cut from 2 x 6-in. Douglas fir plank in lengths up to 30 ft. and were planed to form the sections of the circle. The staves are bound together with ½-in. round medium-steel rods, spaced from a maximum of 10 in. apart on centers at the top of the line to 1⅛ in. apart on centers at the foot of the hill, as shown in an accompanying table. These bands are designed to be stressed to a maximum of 20,000 lb. per square inch.

The pumping plant to which the wood-stave pressure pipe delivers consists of a 16-in. four-stage Worthington turbine pump, driven by four impulse water wheels mounted on the same shaft. This pumping unit is erected on a block of mass concrete built up on solid rock, occupying an 8 x 26-ft. space.

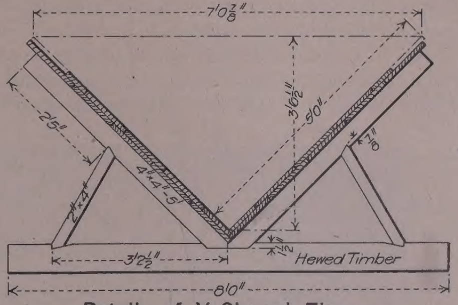
The wood-stave pipe terminates in a cast-iron reducer connecting to a horizontal 18-in. manifold pipe placed in a heavy block of concrete in the rear of the concrete base for the unit. The four wheels are 36 in. in diameter and each has sixteen cast-iron buckets. Water is supplied to each wheel through a 6-in. connection to the 18-in. manifold pipe. Each of these connections is controlled by a hand-operated gate valve and terminates in two 2½-in. brass nozzles from which water is directed against the buckets of the wheel. The wheels are covered with a light temporary wooden box, simply to prevent the diffusion of spray from them. The shaft of the wheels is direct-connected to the shaft of the pump by a flexible coupling built up of leather links, in order to provide for operating emergencies. The shaft of the wheels is carried by two standard ball-and-socket bearings, and the shaft of the pump by two standard Worthington turbine pump bearings. A standard babbitted-collar thrust bearing is placed on the opposite end of the pump shaft from the wheels to provide for any unbalanced thrusts.

A Section of the 100-Second-Foot V-Shaped Flume.

Water Wheels and Pump on the Pressure Line.

The suction of the pump is connected to the 18-in. horizontal manifold pipe, from which water is supplied to it at a pressure of about 175 lb. per square inch. The pump discharges the water at a pressure of about 330 lb. into an 18-in. pipe that connects in the block of concrete in the rear of the pump with the 24-in. riveted-steel pipe leading up the hill to the point where sluicing operations are in progress. All of the piping connections to the pump are of cast steel. The unit is designed to operate at 475 r.p.m. and to deliver 7,000 gal. per minute at this speed under the operating conditions. No governor is provided, as the unit is operated at a continuous speed.

The shell of the 24-in. riveted-steel pipe varies in thickness from 5/16 in. at the lower end of the line to No. 12 Gauge at the top of the hill, the steel being stressed to a maximum of 18,000 lb. to the square inch. The longitudinal joints of this pipe are of double-riveted lap type. The pipe was built in the shops of the East Jersey Pipe Co. in 30-ft. sections to reduce the freight charges and to facilitate delivery. It was laid on the surface of the ground without making much excavation, and was anchored at various intervals by means of wire cables attached to lugs riveted to the pipe.



Details of V-Shaped Flume.

The country in which this plant has been installed is covered with dense, heavy fir timber, through which no wagon roads had been built at the time the work was undertaken. A standard-gauge logging railroad had been extended to a point within two miles of the site of the work, so a wagon road was constructed through the dense timber from this railroad to the plant. On account of the heavy rainfall in this region and the character of the soil, this road had to be covered for almost its entire length with split logs, placed transversely across it. The pumping unit, the steel pipe, the lumber for the flume and wood-stave pipe, and all camp equipment was brought in over this "corduroy" road. As the pump weighed about 45,000 lb. it was bolted to a skid and hauled along with a donkey engine from the end of the railroad to the site. Even then it was brought in with difficulty, because the country close to the site of the plant is particularly rough and densely timbered.

The 24-in. riveted-steel pipe ends on the east side of the large embankment, close to the limits of the cut on that side. At the end of this pipe three 16-in. machine-banded wooden-stave branch lines are carried to the faces of the different excavations. One of these lines extends to the east to a pit that has been opened on that side of the hill through which the 450,000-yd. cut to the east of the large embankment is being made. The material from this pit is utilized to make the 100,000-yd. embankment. A second 16-in. line extends from the end of the 24-in. pipe to a pit on the side of the hill adjacent to the 700,000-yd. embankment, the material from this pit being sluiced into that embankment. The third 16-in. branch line follows around the uphill end of the gulch, across which the large embankment is beign made, to the west side of this gulch, where it delivers water for operations in the 350,000-yd. cut on that side. The materials sluiced from this cut are also delivered into the large embankment.

The sides of the gulch in which the large embankment is being built were exceedingly steep, and rose on both sides to a height of 400 to 500 ft. above the bottom at the point where the center line of the railroad crosses the gulch. The bottom of the latter also drops 200 ft. from the toe of the downhill slope. Above the site of the work the mountain side is very abrupt, the top of the mountain being 3,000 to 3,500 ft. above the river at a distance of less than a mile from the latter. The entire side of the mountain was also covered with a dense growth of fir trees ranging from 3 ft. to 6 ft. in diameter, which had to be cut and their stumps grubbed out and burned before the excavation reached them.

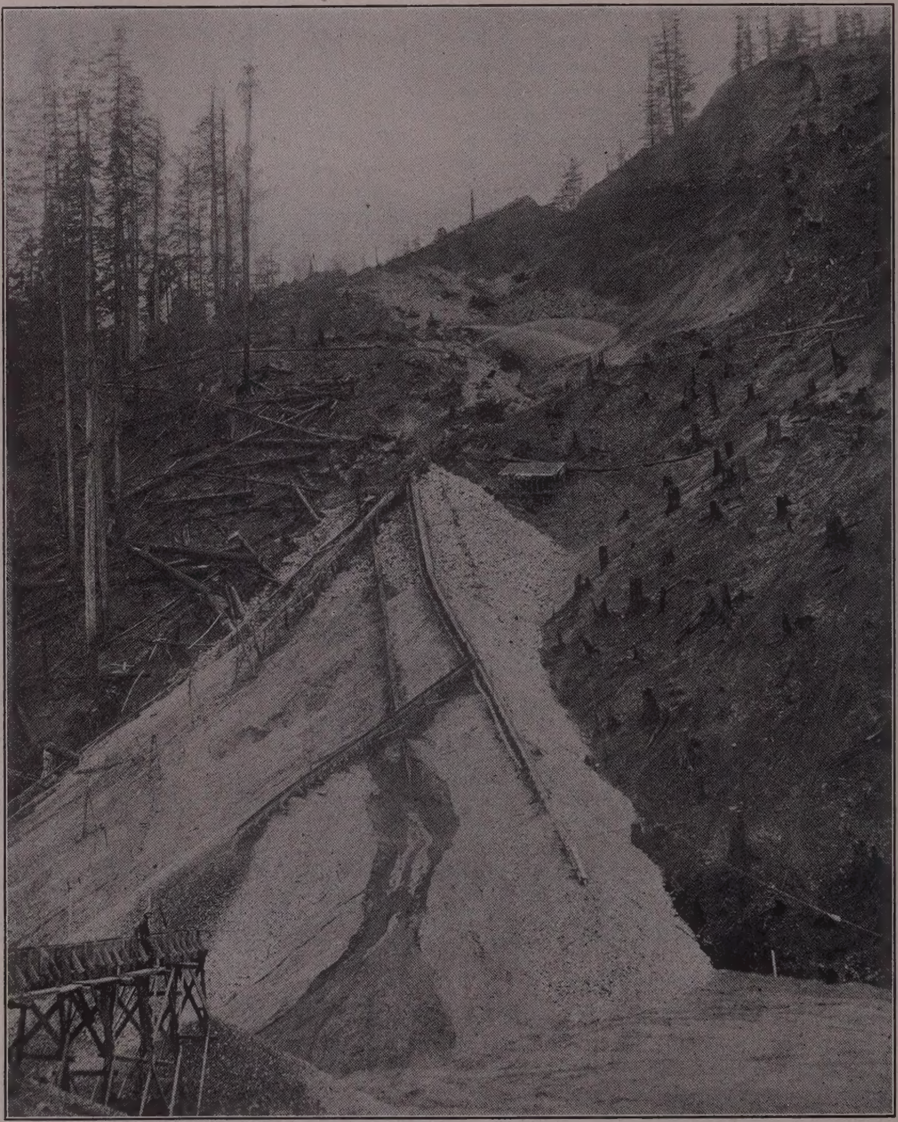
The side of the mountain in the vicinity of the work is covered to a great depth by material deposited from immense glacial movements. The hills on both sides of the gulch are largely coarse, dirty sand, containing a considerable amount of gravel and boulders. At the point where the cut is being made through the hill on the east side of the gulch a much larger percentage of gravel and boulders has been encountered than in the cut on the west side of the gulch. According to the specifications under which the work is being done, boulders having a volume of 1 cu. ft. and less than 13.5 cu. ft. are classed as loose rock, while those larger than the latter size are classed as solid rock. Based on this classification, about 10 per cent. of the material handled from this cut is loose rock and 1 per cent. solid rock. A large percentage of the material in addition to these amounts is gravel and small boulders. The material encountered in the cut on the west side of the gulch is quite different, as it contains a much higher percentage of almost pure sand and soil. The amount of loose rock in this cut is estimated to be about 5 per cent., while a few boulders having a volume of more than 1 cu. yd. have been removed from it. In the small cut on the opposite side of the east hill from the large embankment the material has much the same character as in the main cut in this hill.

The water is delivered at the end of the branches from the 24-in. riveted-steel pressure line from the pumping plant under a pressure varying from 60 to 80 lb., depending on the length of the branch and so forth. Two 6-in. hose connections are made to each branch to deliver two streams at the pit in each cut. The giants ordinarily used in hydraulic-mining operations have not been found necessary in this work, as the water is delivered from each 6-in. hose line through a 3-in. nozzle orifice with sufficient force, under the available pressures, to loosen the materials. In fact, the materials can be loosened much easier than means for their disposition can be provided. The nozzles are mounted on a plank and are easily handled by one man. The normal method of operating in a cut is to maintain the face of the excavation as nearly vertical as is possible, the material being washed from this face by undermining the latter. The loosened material is then washed into races in the bottom of the pit which lead to flumes carried out over the fill. Most of the time is consumed in starting the materials to these races after they have been loosened from the face of the excavation, but the rapidity with which the materials can be started and moved is such that the only difficulty lies in disposing of them. Indeed, if they were to be wasted instead of placed in the embankment, larger nozzles, or giants, could be utilized in making the cut at even a very much higher rate than can be maintained where the materials must be delivered into an embankment.

The face of the cut on the east side of the gulch, with a total height of 240 ft. above the railroad grade, will be about 500 ft. wide at the top when it is finished. In one of the accompanying illustrations showing operations in progress on the east side of the gulch the face of the cut had been carried back to a junction at the top with the smaller cut on the opposite face of this hill. The width of the cut remained to be widened considerably at the time this picture was taken, and the cut was also to be deepened much more. The materials as they are loosened in this cut assume a fairly steep angle of repose from which they are started into the races by the jets from the nozzles. This starting of the materials has to be handled carefully to avoid choking the races and flumes. Boulders having a volume of more than 1 cu. ft. are moved in the races and flumes, however, with little difficulty. The largest boulders encountered are broken up with light charges of dynamite to avoid stoppage of the races.

A main race, 2 x 2 ft. in cross section, is laid on a grade of about 16 per cent. from the edge of the moving mass of materials in the pit to the limit of the cut. This race, which is lined with plank and paved with 4-in. blocks, has branches extended from it to various parts of the pit, as appears most desirable during the progress of the work. Channels are easily maintained to divert the spoil-laden streams into the races, by means of portable guide boards moved from place to place to stop the cutting of the edges of these channels at different points. With two nozzles in operation five men can keep a pit in proper condition.

The materials are delivered into the embankment from the races by means of flumes arranged in such manner that less than 5 per cent. of the volume of materials removed from the cut is wasted. The materials are separated into three sizes as they come from the cut: large boulders, small boulders and gravel and fine gravel and sand. The race was first continued from this cut out over the gulch in a flume, 2 x 2 ft. in cross section, which was built up on a temporary pole trestle, having A-frame bents with a maximum height of 80 ft. This first flume was extended slightly downhill from a line normal to the bottom of the gulch, and was built out from the face of the hill as the embankment was made from it. After the embankment had been carried up nearly to this first flume, a second one was extended out on a pole trestle in the same manner, except that it was inclined up the gulch, with a branch from it in the opposite direction at a point half way down the hill. The small boulders and gravel are delivered by these flumes, while the large boulders are diverted at the head of the latter into another flume and the fine material is delivered into the embankment by still another flume.



Sluicing in Progress on East Side of Deep Gulch.

The separation of materials is made by means of two gratings, or grizzlies of iron bars, which replace two sections of the bottom of the main flume immediately outside the limits of the cut. The flow of water carrying the spoil through the race from the pit at the face of the excavation is first passed over a grating of ¾ x 3-in. bars, spaced 6 in. apart. All the water and the materials, except the large stones, fall through this grating, which is 12 ft. long, into a continuation of the flume underneath. The velocity of the water and spoil is sufficiently high at the grating to cause the stones retained on the latter to continue over the grating into the flume through which they are diverted into the embankment. Two men are generally stationed at this point, however, to loosen stones which become fastened in the grating and to break jams. These men, together with a third, also tend the balance of the flumes on that side of the embankment.

The water and materials which fall through this first grating into the flume below are passed over a second grating, 10 ft. long, that has ⅝ x 3-in. bars, spaced ½ in. apart. Most of the water and the fine gravel and sand fall through this second grating into a short flume leading to settling bunkers under the main flume. The balance of the materials, consisting of small boulders and coarse gravel, continues beyond the second grating in flumes leading out over the embankment and is deposited from these flumes into place. As most of the water passes through the second grating, a stream from a 3-in. pipe is turned into the flume beyond that grating to move the materials. Since the flumes are built on grades of upwards of 25 per cent., only a comparatively small volume of water is required for this purpose, and this water immediately settles through the fill at the end of the flume.

The settling bunkers to which the sand and fine gravel passing the second grating are delivered are about 14 x 14 ft. in plan and 12 ft. deep. The water largely overflows from these bunkers and is wasted through a closed flume leading down the face of the hill to a point below the toe of the outer slope of the embankment. The sand and fine gravel are drawn through a gate at the bottom of these bunkers into the sluice which delivers them into the cut. The lower end of this sand and fine gravel flume is always maintained on the uphill side of the point where the coarse gravel and small boulders are being discharged. In this manner the water by which the fine materials are carried is required to settle through the fill, so it deposits almost everything that is in suspension in it before reappearing on the downhill side of the embankment.

The methods employed in making the cut on the west side of the gulch are generally the same as those followed on the east side. The almost entire absence of large boulders in this hill, however, precludes the necessity of the coarse grating at the head of the flumes. On the other hand, the much larger percentage of sand requires two settling bunkers, which are placed together under the main flume in the same relative position as in the other case. As the amount of sand and fine gravel is in excess of the coarser materials on this side the discharge from these bunkers has to be deposited in the embankment with considerable care to insure that the water will pass through sufficient material before reappearing on the downhill side of the embankment to deposit practically all of the fine sand and soil particles carried by it. This result has been fully accomplished by careful manipulation of the flumes. In the accompanying view, showing the cut and embankment on the west side of the gulch, the broad flat area of sand on the uphill side of the coarse gravel and boulders in the fill may be readily seen.

The sides of the races and flumes are built of 2 x 12-in. plank, and as the principal wear comes on the bottom, the latter are lined with blocks of wood 4 in. thick, having the grain of the wood perpendicular to the direction of flow. In general, no angles are made in the flumes, except at the point where the materials are separated and where branches are taken from the main flumes. At these angles the sides of the flume are shod with steel plates to take the excessive wear. With these arrangements comparatively little difficulty is experienced in maintaining the flumes, although the percentage of materials carried by the water is generally very high and the velocity of flow in the flumes is at all times great.

The water delivered from the ends of the flumes with the materials, at first reappeared just above the original ground level on the downhill side of the embankment, and was carried away in the natural water course in the bottom of the gulch. As the height of the embankment increased the point where the water appeared rose on the side of the outer slope. In order to prevent the washing of the latter, this water is carefully diverted into open channels in this slope, which channels are kept of short length and deliver into closed pipes that carry the water beyond the limits of the slope. The collection and diversion of this water are thus obtained with comparative ease, since the bulk of the water generally appears in a limited area.

The coarser gravel and small boulders are deposited from the flumes until the pile of materials at the end of the latter reaches a considerable height. The sides of these piles finally slip down to the angle of repose of the material, which is about 1¾ to 1 slope. The outer main slope of the embankment is maintained at about this angle by means of low terraces confined by brush and boughs. The sand and fine gravel immediately take a slope of about 1 to 10 as they are deposited from the flumes, but are all confined back of the outer part of the fill formed by the coarser materials.

The smaller cut on the opposite side of the hill to the east of the large embankment is being handled in the same general manner as is the one on the side of that hill adjacent to that embankment. The material from this smaller cut will be carried about 400 ft., on an average, to make the 100,000 cu. yd. of embankment adjacent to it.

The hydraulic mining and sluicing operations are carried on continuously with two 12-hr. shifts, without regard to weather conditions. Although these operations have been under way during the period of excessive rainfall which occurs on the western slope of the Cascade Mountains, the work has not been stopped since it was started, except for a few brief periods. The chief difficulties that have been experienced have been due to large trees falling on the pipe lines. During the month of February, on an average, 5,000 cu. yd. of material was removed from the cuts and placed in the embankment each 24 hr., while in March an average of 6,000 cu. yd. per 24 hr. was maintained for the month.

The sluicing plant was installed and the work is being handled by the Smyth Contracting Co., of Seattle, Wash. This journal is indebted to Mr. E. W. Cummings, of that company, who designed and installed the sluicing plant, and is supervising the operations, for the information from which these notes were prepared.

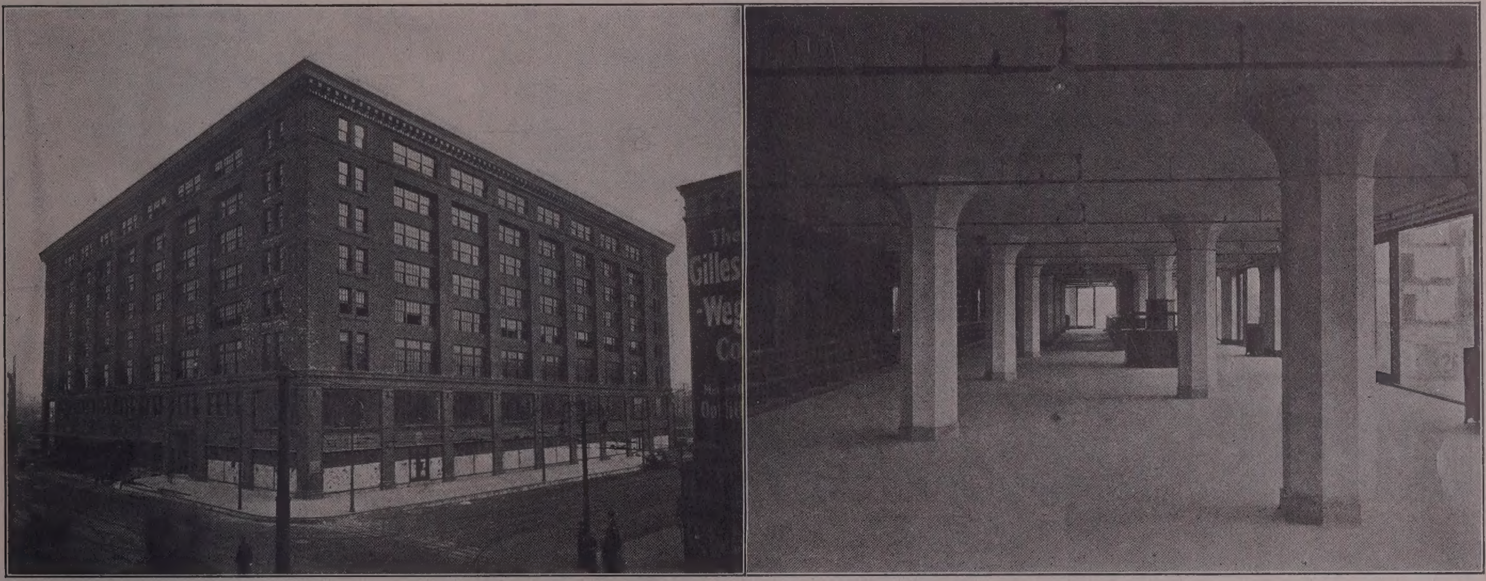
The Bostwick-Braun Building, Toledo, Ohio.

By C. A. P. Turner, M. Am. Soc. C. E.

In presenting a short description of this interesting structure the writer would call attention to the following unusual features: First, the extreme simplicity of the centering; second, the remarkable rapidity of construction, unexcelled, so far as the writer knows, in the erection of any building on record; third, to the satisfactory tests withstood by the construction, and, finally, to the satisfactory appearance of the finished building.

The building is 220 ft. on each of the street fronts, is eight stories in height, and designed for wholesale hardware purposes, with the capacity of 500 lb. per square foot and 350 lb. per square foot for the various floors. These loads are taken over the full floor area, which would permit piling heavy material, such as plates, up to 700 or 800 lb. per foot over one-half the area of any panel, and 1,000 lb. or more on floors designed for 500-lb. capacity.

The foundations of the buildings were carried down to a conservative depth through clay, and while this was slow and expensive work, there was nothing out of the ordinary in the type adopted. The building faces the river front and has facilities for shipping both by rail and water. An open face, one panel in width, is left along the river front in the first tier, and the railroad spur is carried into this section.

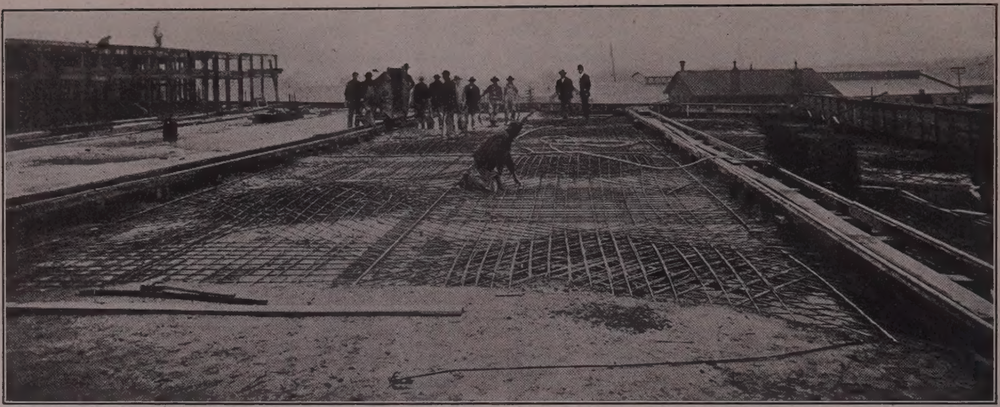


Exterior of the Bostwick-Braun Building and Interior View of One Floor.

The general details of the reinforcement of the building is shown in the accompanying illustrations, giving the standard details of this type of construction together with various details for special columns. The floor reinforcement is of the standard mushroom type; this system consists essentially of a circular cantilever supporting system and of belts of reinforcement running directly and diagonally from support to support over this supporting system. The supporting system is made up generally by bending column reinforcement outward into the slab, or by its equivalent in carrying rods across the column and sometimes by elbow rods.

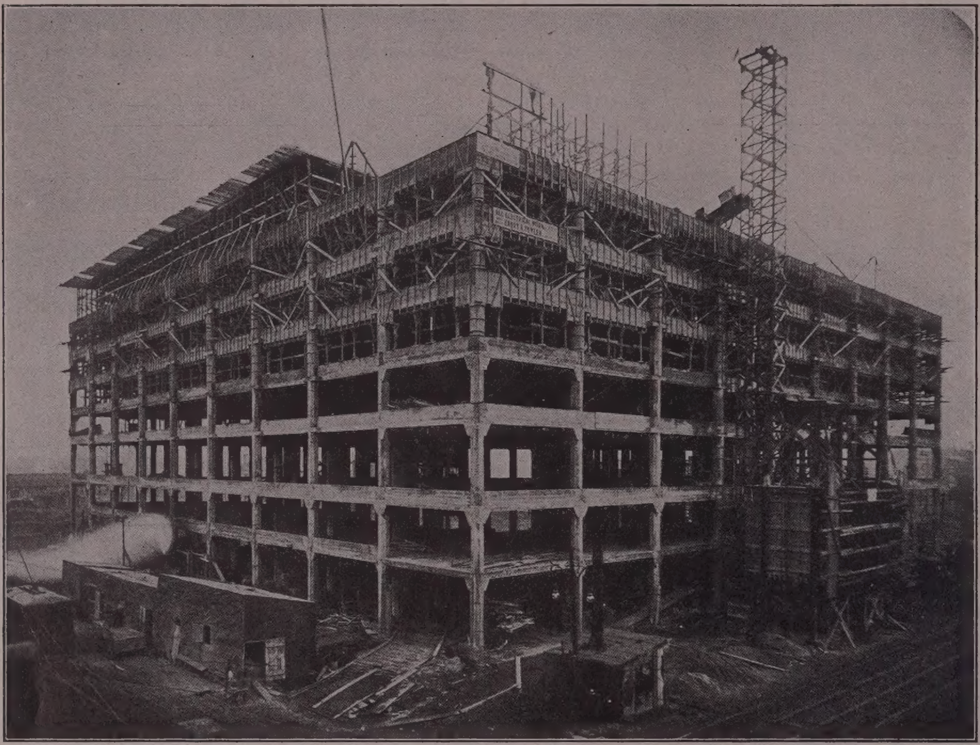
The advantages of this method of floor reinforcement are as follows: The floor plate proper is a circular plate carried at its outer edges by the circular supporting systems. The concrete is strained in a number of directions and all the advantages incident thereto are gained; while it is further tied together so thoroughly that temperature cracks will not occur, and a larger margin of safety is secured since, with the material so tied together, a sudden collapse is almost impossible.

The third floor was tested by placing about 2,000 kegs of nails, thirty tons of solder in boxes, and pig lead piled on the top of the nails, in the center of a panel. This load was equivalent, approximately, to 1,000 lb. per foot of floor over the full panel, though on account of the way it was piled there was 1,300 or 1,400 lb. per foot in a small area at the center of the panel. There was evidently little or no opportunity for the load to arch or distribute itself in that way, and the weight carried may be regarded as double the worst combination of load possible in a hardware building.



View of the Floor Reinforcement in the Bostwick-Braun Building.

The unusual rapidity of erection may be realized from the statement that from 5,000 to 6,000 sq. ft. of floor per day, including the columns, placing the reinforcement and concrete, was put up for thirty days' running, as soon as the constructors got above the foundations and had the work really under way.



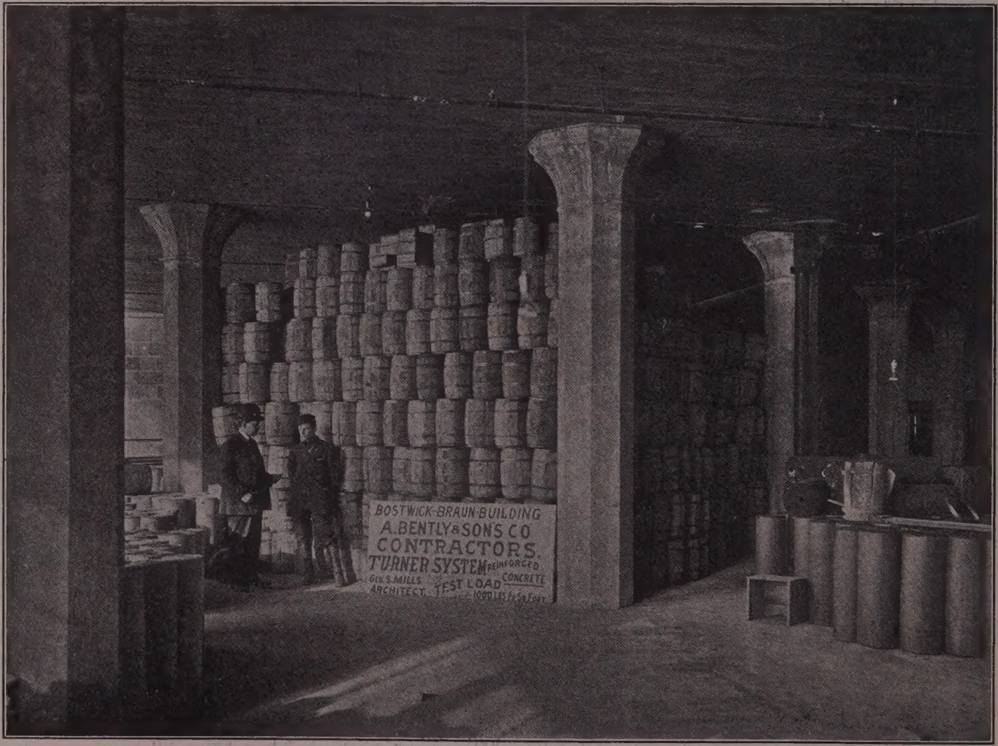
View from Street Front Showing Contractors' Plant.

In the columns that combination of vertical steel and hooping has been adopted which has shown itself, by test, capable of developing 8,000 lb. per square inch of core area before scaling or checking of the concrete occurs outside of the hoops, and possessing an ultimate strength of approximately 11,000 lb. per square inch. In the iron storage room the columns are about 26 ft. in height and 26 in. in diameter, octagonal in form. The same cast-iron heads for the forms were used for all sizes of columns throughout the building, and the same stays for the strapping together in the column boxes. The office portion of the building is finished in hard plaster with a terrazo floor, and the octagonal columns and ornamental caps give the room a unique and attractive appearance.

In the arrangement of the building the requirements for wholesale hardware purposes were about as follows: Lines of shelving were required, about 12 ft. center to center; hence, the column spacing, longitudinally and transversely, had to be 12 ft. or the multiple of twelve. In this building, in view of the fact that the economic spacing of columns would be in the neighborhood of 17 to 20 ft., the columns were spaced 17 ft. center to center on diagonal lines, thus placing them 24 ft., center to center, parallel to the main walls of the building on the street fronts.

This arrangement secured a more pleasing artistic treatment of the exterior and better show windows without increasing the cost and meeting, at the same time, the requirement regarding the shelving. As will be noted from the plan, the building is not square in form and the somewhat irregular arrangement of columns, necessitated by the track and water front, caused no inconvenience whatever in the layout of this particular type of construction. In fact, there is probably no method of reinforcement which adapts itself so readily to any form, shape or type of building as the mushroom system. It has been used to date in about five to six million square feet of floor, and has to its credit no record of failure or injury to workmen engaged in its erection.

When we are discussing the safety of structural steel buildings, perhaps there is a chance for the concrete constructor to put in a word for the type which he advocates, not only on the ground of superior economy and rapidity of erection, but also on the broader ground of greater safety to the workmen putting it up, a more ample margin of safety in the working values that he is using and the elimination of such uncertainties as are developed in steel construction, where there is greater doubt about the strength of the large column than that of the smaller, while the reverse is true with concrete construction. The larger the column, the more uniform our tested results, and the greater cer-



Test Load on a Panel of One of the Floors.

tainty that there will be little variation from the figures of the competent designer.

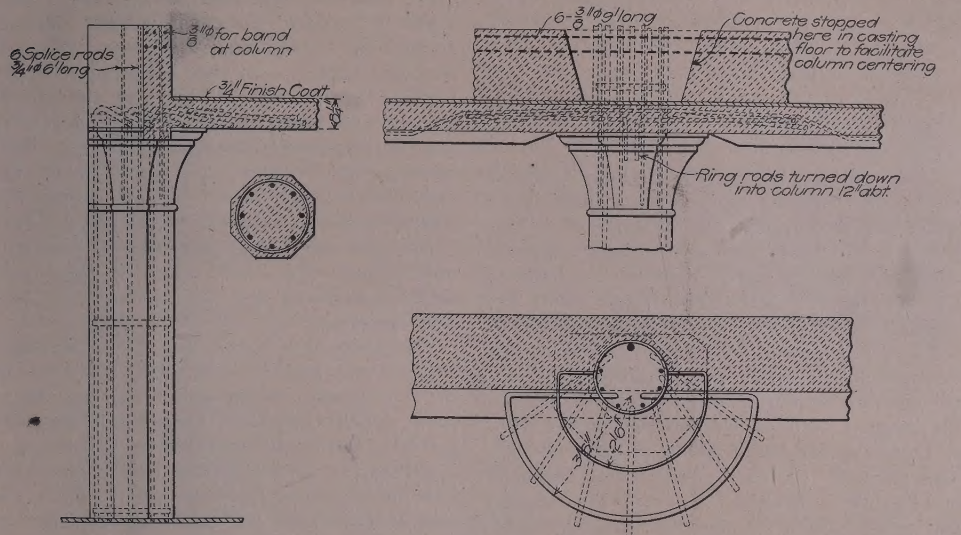
It may be noted in this connection that the columns used in the building illustrated are of a type in which there is no metal to interfere with a sound and substantial casting from floor to floor, and that that portion of the column which is depended upon to carry the load is a cylinder with no metal reinforcement crossing it between floors. It may be further observed with regard to the character of the columns, that they are proportioned with due reference to the proper restraint of the concrete. We have had in the last year a considerable amount of test data published on hooped columns which was misleading to a large extent in view of the radically improper design of the test specimens. For example, columns have been tested and the results quoted as a fair illustration of what might be expected of a hooped column, without reference to the proper percentage of vertical steel to restrain the concrete against flowing upon itself laterally as the hoops are brought into action.

The difference in the deportment of the two types is quite radical. The column in which a suitable percentage of vertical steel has been used, combined with a proper degree of hooping, does not commence to show distress under 80 per cent. of its ultimate strength; while a column which has been merely hooped, without due regard to the proper percentage of vertical reinforcement, will frequently commence to scale and check under four-tenths to five-tenths, and sometimes under even a smaller proportion, of the ultimate strength which it may develop. In fact, the writer does not hesitate to express the opinion that 90 per cent. of the literature of reinforced concrete must be rewritten along lines which pay some attention to the peculiarities of the material, rather than along lines which are merely a feeble imitation of older types of construction, and an endeavor to make the materials apply to a preconceived, old-style theory, rather than to make the theory of construction apply, naturally, to the materials which the constructor is called upon to use, and to use those materials in the most advantageous manner possible, even though it may involve special investigation to determine the correct theoretical treatment.

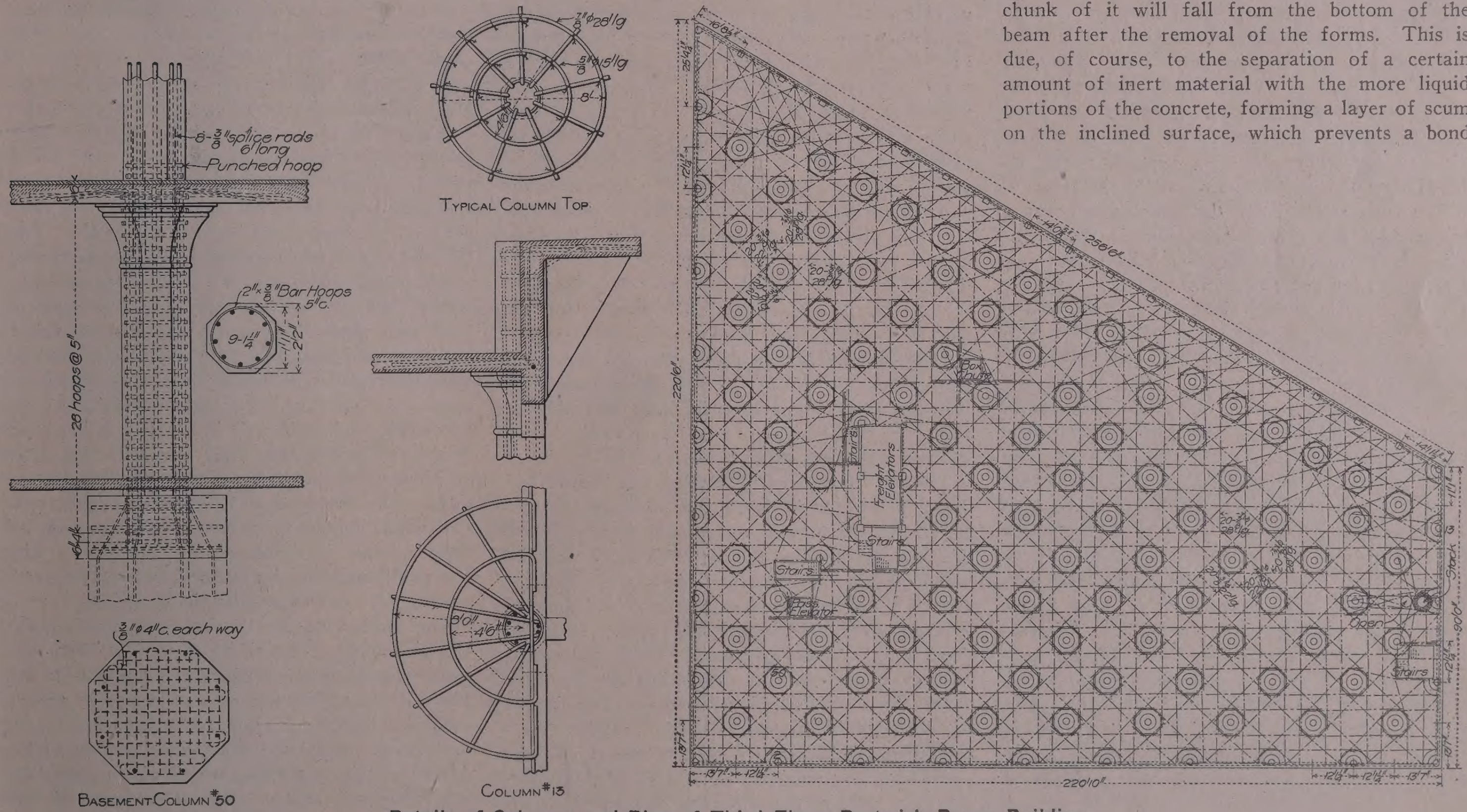
In point of cost the type illustrated presents a considerable advantage, probably in the neighborhood of 15 to 25 per cent, over types in which less attention has been paid to the economy of centering, and the advantageous working of the materials. This economy is greater the heavier the load, and less as the load becomes lighter and the spans increase in length. The system has been built with spans a little over 30 ft. Its advantage under concentrated loads, or under machinery which would ordinarily cause considerable vibration in a structure, lies in the fact that the whole slab, and almost the entire reinforcement in the slab in a panel, is brought into play under any concentrated load. Hence, this type of construction presents unusual freedom from vibration under the most trying conditions, such as supporting gas engines and the like.

Another practical advantage lies in the fact that there is no opportunity to leave out important reinforcing members. A glance at the floor will indicate whether everything is in shape to proceed with the concrete. The fact that the slab is of uniform thickness throughout permits the rapid placing of the material and avoids one of the serious practical difficulties in concrete construction, that of securing a perfect bond between the new and the older work.

For example, where ribs are used the depth of the rib gives a certain head under which the semi-fluid or plastic concrete will flow. It is sometimes difficult to stop the work in a vertical line, and the long thin wedge of material left as the work stops on the beam does not bond satisfactorily to the new work, and frequently a chunk of it will fall from the bottom of the beam after the removal of the forms. This is due, of course, to the separation of a certain amount of inert material with the more liquid portions of the concrete, forming a layer of scum on the inclined surface, which prevents a bond with the new work unless the surface is broken up. With the mushroom system, the head which the concrete has under which to flow is merely the thickness of the slab, or about one-fourth to one-sixth that which it would have with ribbed construction. Hence, this difficulty is largely obviated and the material can be placed in a more plastic condition to advantage, with greatly reduced difficulty in bonding between the old and the new work. From the fireproof standpoint the type here illustrated presents some interesting claims for consideration. Its flat slab has no ribs to be unequally heated; there are no concentrations of large rods insufficiently pro


3/8"φ for band at column
6 Splice rods 3/4"φ 6' long
3/4" Finish Coat
6-3/4"φ 9' long
Concrete stopped here in casting floor to facilitate column centering
Ring rods turned down into column 12" abt.

Details of Third-Story Column Number Two.



TYPICAL COLUMN TOP

BASEMENT COLUMN #50

COLUMN #13

Details of Columns and Plan of Third Floor, Bostwick-Braun Building.

tected, as in the bottom of ribs; and the multiple way reinforcement so ties the work together that it is found to withstand severe stresses from high temperature with the minimum amount of damage.

In the reinforcement of the building no high carbon steel was used, but all rods were of good tough medium steel, meeting the requirements of the Manufacturers' Standard Specification. The exterior walls are built of hard burned red brick, trimmed with terra-cotta to match. The walls were carried up in about thirty days' time after the skeleton of concrete was complete.

Credit for the design and general arrangement of the Bostwick-Braun Building is due to Mr. Geo. S. Mills, architect, Toledo, O., and his engineer, Mr. Geo. V. Rhines, of Toledo. The A. Bentley & Sons Co., of Toledo, were the contractors, the writer acting as consulting engineer for the contracting company, in connection with the system of reinforcement used.

Experiments with Dust Preventives on a Road at Wayland, Mass.

During the past few years a number of preparations for laying and preventing dust on road surfaces have appeared on the market in competition with crude materials such as coal tar and petroleum, and it was therefore decided by the Office of Public Roads of the Department of Agriculture to carry on a series of experiments during the summer of 1907 with a view to determining, if possible, their adaptability to different conditions. It was learned that the Highway Commission of Massachusetts intended to treat a stretch of road leading into Boston with a tar preparation, and arrangements were made by which the Office of Public Roads could carry on a number of experiments on sections of this road. The following notes are taken from an official circular concerning the tests, recently issued by Mr. Logan Waller Page, director of the Office.

The road selected for the experiments was a mixed trap and granite macadam in the townships of Weston and Wayland, which had been built about ten years previously and had had but few repairs since that time. It is part of the main thoroughfare connecting New York with Boston and about 16 miles from the center of the latter city.

The automobile traffic is for this reason heavy, and this, in addition to teaming and other traffic, had produced serious results. In some cases the macadam was completely broken through. There were many rut holes, some of them 30 ft. long and averaging from 1 to 3 ft. in width, and a large number of smaller holes more nearly circular in shape. Over almost the entire road surface numerous small depressions or worn places were visible and practically all of the fine material was being removed by traffic as fast as it was formed. The No. 1 or large-size stones protruded above the surface, and in many cases were scattered loose, making the road extremely rough. Every rapidly moving automobile which passed would, in dry weather, raise a cloud of dust, which would be blown over the surrounding country, causing considerable annoyance to nearby dwellers as well as damage to the road. Sections of this road as nearly alike as possible were selected for the experiments, which were made with water-gas tar, crude coal tar, various mixtures of the two applied in different ways, and a special coal-tar product.

The water-gas tar was obtained from a local gas company at $1.50 per barrel of 50 gal., delivered. It was a thin, oily liquid, having the properties shown in Table 1. The crude coal tar was also obtained from a local gas company in 50-gal. barrels at $2 per barrel, delivered at Wayland. It had been produced at a comparatively low temperature and contained a good pitch base. The special coal-tar product was supplied free of charge by the manufacturing company in 50-gal. barrels. It contained no water, was free from the extremely volatile oils present in the crude tar, and held a good pitch base. Its other properties are shown in comparison with the water-gas and coal tars in Table 1.

TABLE 1.—SPECIFIC GRAVITY AND PERCENTAGE COMPOSITION OF TAR PRODUCTS.

Kind of tar.	Specific gravity.	Ammoniacal water.	Total light oils to 170° C.	Total dead oils, 170°-270° C.	Residue, per cent by difference.
Water-gas tar....	1.041	2.4	[a]21.6	[b]52.0	[c]24.0
Coal tar	1.210	2.0	[d]17.2	[e]26.0	[f]54.8
Special tar preparation........	1.177	0.0	[b]12.8	[g]47.6	[f]39.6

[a] Distillate mostly liquid.
[b] Distillate all liquid.
[c] Pitch very brittle.
[d] Distillate mostly solid.
[e] Distillate one-half solid.
[f] Pitch hard and brittle.
[g] Distillate one-third solid.

Labor was furnished to the Highway Commission under contract, the contractor receiving a stated per diem salary and a bonus of 15 per cent. of the actual cost of the labor supplied. This cost per eight-hour day was as follows: Common labor, $1.50 to $1.85; single teams, $3; double teams, $5; foreman, $3; steam roller, $12.

Two steam rollers were employed, and as one belonged to the Highway Commission, the cost per diem of running it included only the hire of the engineer at $2.50 per day and cost of fuel. A 12-bbl. heating kettle with a portable fire box and mounted on wheels, stiff street-sweeping brooms, picks, shovels, etc., a 2-horse sweeper, and a tank wagon for the water-gas tar, constituted the outfit necessary to carry on the work.

As the road was in bad condition, it was found necessary to make extensive repairs before applying the tar. The places to be repaired were first loosened with hand picks and the No. 1 stone separated from the finer material and returned to the holes, after which enough No. 2 stone was spread to give as nearly as possible an even surface to the road when rolled. There were, however, numerous small depressions or worn places which were too shallow to patch successfully, but deep enough to give the road an uneven appearance when completed. In one section it was found necessary to resurface the road completely. All extra material needed for repairs was taken from piles which had been previously distributed along the road by the Highway Commission, but in estimating costs, the value of the crushed rock in place was allowed for. The cost of repairs per square yard of road surface was from 2.6 to 3.3 cents.

The tar was applied during the month of August and only in dry, warm weather. Before the road was entirely completed it was found necessary to remove the dust and waste material which had accumulated and been swept into the gutters. This had to be carted away and dumped in convenient places near the road. It added from 1 to 1.3 cents per square yard to the total cost of treatment. In estimating the cost per square yard of the different sections, these figures are included in proportion to the length of section treated. Work of a general nature, such as unloading, hauling, etc., is also divided proportionately among the different sections in computing the cost. Thirteen different experiments were made, four with water-gas tar alone, three with coal tar, three with mixtures of water-gas tar and coal tar, and three with special tar preparations. The following is a brief description of each, with a statement of cost and the results obtained after three months:

Water-Gas Tar, 1.—A section of road having numerous ruts and holes was first thoroughly swept and repairs made where required. It was found necessary to have the sweeping done first, in order to prevent the sweeper from tearing up the loose stones in the patches. The unheated water-gas tar was then spread upon the road from the tank wagon and well broomed in. It was readily absorbed by the road surface and failed to hold a light coat of gravel which was spread and rolled down. Another application of tar was then made, and sufficient gravel added to absorb the excess tar completely. The surface was then well rolled, but refused to compact properly and showed a strong tendency to pick up under the roller where the road was patched. Indications pointed strongly toward a failure, but after the road was subjected to traffic for a few days it was noticed that its appearance was somewhat improved, although the patches showed signs of raveling. In damp weather the road showed up to advantage and no disagreeable mud was noticed, even after heavy rains. In dry weather the dust was well laid and, although the top was not firmly compacted, it seemed to remain in place under the action of traffic. When inspected three months, later, the road was in a much better condition. The loose surface had packed down well and the patches were holding much better than was to be expected from earlier observations. The road at that time was practically free from dust and presented a fairly good appearance.

The section thus treated was 1,275 ft. in length. The tar was applied for a width of 12 ft., and with an average of 0.9 gal. of tar per square yard. If the road had contained fewer holes and been less in need of a heavy top dressing, a much smaller quantity of tar could undoubtedly have been made to give the same results. The cost of application was 4.9 cents for labor, 2.7 cents for tar, and 0.8 cent for gravel per square yard, and this, added to the cost of repairs, 3.2 cents, and of removing refuse material, 1.3 cents, makes a total of 12.9 cents per square yard. The entire area covered was 1,700 sq. yd. Thirteen and one-third cubic yards of gravel were applied and 15 cu. yd. of refuse material removed.

Water-Gas Tar, 2.—The section of road treated in this experiment was in about the same condition as the preceding one. The cost of repairs was about the same per square yard, but there were not so many large holes to be patched. The tar and gravel were applied in the same manner to the road, which had been well swept and repaired, but in this case only one treatment of each was given. The surface was well rolled, but as in the preceding case, it did not compact well, although no tendency to pick up under the roller was observed. The surface improved under traffic and held well in rainy weather. No dust was formed and, after one week, but little difference could be detected between the two sections. The color of this section, however, was somewhat lighter than No. 1. At the end of three months it compared very favorably with No. 1, although the surface was not quite so well compacted. It was practically dustless.

This section was 125 ft. in length, and application was made over a width of 12 ft. There was used on each square yard treated 0.38 gal. of tar. The cost of application was 4.9 cents per square yard for labor, 1.1 cents for tar, and 0.8 cent for gravel. Repairs cost 3.3 cents, and removing waste material 1.3 cents, which gives a total of 11.4 cents per square yard. One hundred and sixty-seven square yards were treated, 1 1/3 cu. yd. of gravel applied, and 1½ cu. yd. of waste material removed.

Water-Gas Tar, 3.—For the purpose of determining the value of water-gas tar as a dust layer, without reference to its value as a surface binder, a section of road which was in excellent condition was sprinkled with this material. An ordinary sprinkling cart was used, and no attempt was made to clean the road surface before treatment. As much tar was applied as the road would absorb without becoming too muddy. No dressing of screenings or gravel was applied. When dry, the road showed a much darker color, the dust was well laid, and no formation of dust was noticed for two weeks after treatment. At the end of three months very little dust was raised by a rapidly moving automobile, and the road surface seemed to be considerably hardened by the residual matter retained after the more volatile products of the tar had evaporated.

A length of 300 ft. of roadway was treated in this manner for a width of 15 ft., and 0.3 gal. of tar applied per square yard. For the short section treated, the cost of labor amounted to 0.6 cent per square yard, and the material 0.9 cent, making a total of 1.5 cents per square yard. For long stretches of road, however, the cost could undoubtedly be cut down to slightly over 1 cent per square yard.

Water-Gas Tar, 4.—For this experiment a short section of road in good condition was selected, in order to make a direct comparison with No. 3. In this case the road was first carefully swept and the tar allowed to run upon it from barrels and thoroughly broomed in. A sprinkler would have served the purpose equally well, but the section was so short that it was not considered worth while to apply the tar in that way. In this case the road would absorb only 0.25 gal. of tar per square yard. It presented much the same appearance as in experiment No. 3, but owing to the removal of all of the dust and fine material it was rougher and therefore less satisfactory. No dust formed, even at the end of three months, but the road at that time lacked the thin cushion of fine material that was held by No. 3. From these two experiments it is evident that the presence of dust and other fine material on the road is rather beneficial than otherwise when water-gas tar is applied.

A section of roadway 150 ft. long and 12 ft. wide was treated in this way. The cost of application amounted to 1.3 cents per square yard for labor and 0.8 cent for material, while the cost of removing waste material from the gutters was 1.2 cents, making a total of 3.3 cents per square yard. An area of 200 sq. yd. was treated, and 1.8 cu. yd. of waste material removed.

Coal Tar, 5.—The section selected for this experiment was in about the same condition as that for experiment No. 1. Large ruts and holes were numerous and had to be patched after the road had been carefully swept. The coal tar was first heated to a temperature of 180° F. in the kettle, and then run upon the road from a hose connected to a draw-off at one end. A team of horses was necessary to move the kettle along the road in advance of the laborers, who spread and worked the hot tar with brooms into the road surface as fast as it was run from the kettle. Four men were required to do the brooming, while the foreman attended to running the tar from the kettle and supervised the work. Cords attached to stakes driven along the sides of the road were first used to measure the width to be tarred, but, after the laborers gained some experience, it was found unnecessary to do this, as they were then able to keep a fairly even line by eye. A coat of gravel was spread over the road soon after the tar had been applied and rolled down to a smooth, even surface during the same day. The large patches showed a tendency to wave and pick up under the roller, but the rest of the surface was well consolidated. After one week's service but little dust was raised by passing automobiles and at the end of three months the road was dustless and presented much the same appearance as asphalt, although the large patches were a little rough. The road seemed to shed water well and dried quickly after a rain.

The section thus treated was 150 ft. in length, 15 ft. wide, and 0.6 gal. of tar was applied per square yard. The cost of application was 6.1 cents per square yard for labor, 2.4 cents for tar, 0.8 cent for gravel, 2.6 cents for repairs, and 1 cent for removing waste material, which gives a total of 12.9 cents per square yard. An area of 250 sq. yd. was treated, 2 cu. yd. of gravel applied, and 2¼ cu. yd. of waste material removed.

Coal Tar, 6.—This experiment was made in the same manner and on a section of road similar in every respect to No. 5. A small quantity of the cold tar was first tried, but was not absorbed by the road, and could not be broomed to any advantage. It was found necessary to heat the tar to a temperature of 145° F. before it could be used satisfactorily, but when applied at this temperature gave results in every way as good as No. 5, although slightly more tar was required per square yard than in that experiment. In this case, as in No. 5, the patches were not entirely satisfactory. A somewhat longer stretch of road was treated in this experiment and, although slightly more tar was used, the cost of application per square yard remained the same, as the labor item was lowered. The section was 600 ft. in length and 15 ft. in width, and 0.7 gal. was applied per square yard. For this application labor cost 5.6 cents, tar 2.8 cents, gravel 0.9 cent, while repairs cost 2.6 cents, and removing waste material 1 cent, making a total of 12.9 cents per square yard. An area of 1,000 sq. yds. was treated, 8 cu. yds. of gravel applied, and 9 cu. yds. of waste material removed.

Coal Tar, 7.—In order to get the best results possible with coal tar a section of road free from holes was selected. The road had been badly worn and the surface was somewhat rough, but was in good enough condition to provide a fair test. No preliminary repairs were made, but the road was well swept, as in the case of the other two experiments with coal tar, and the tar applied and broomed in in the same way at a temperature of 195° F. A heavy coat of gravel was then applied and well rolled and compacted, in order to produce a smooth surface when completed. For some time afterwards the road was slightly dusty, but at the end of three months it presented a better appearance than the other two sections, although not quite so much like asphalt. At that time it was practically dustless.

This section was 450 ft. in length and was covered for a width of 12 ft. Only 0.42 gal. of tar was applied per square yard. The cost of application was 4.4 cents per square yard for labor, tar 1.7 cents, gravel 1.4 cents, and removing waste material 1.3 cents, which makes a total of 8.8 cents per square yard. An area of 600 sq. yds. was treated, 8 cu. yds. of gravel applied, and 5 2/5 cu. yds. of waste material removed.

Water-Gas Tar and Coal Tar, 8.—A section of road containing many ruts and holes had been treated with water-gas tar in the same manner as No. 2, in which section it was first intended to be included. As gravel could not be applied the same day, however, and as the surface on the next day was too dry to hold down a top dressing, it was decided to finish the work by applying coal tar before spreading the gravel. The coal tar was applied in the same manner as in experiment No. 5, as was also a top coating of gravel which was afterwards well rolled. This section was inspected three months afterwards and it is very doubtful if the presence of the water-gas tar was of any advantage.

The section treated was 250 ft. long and 15 ft. wide, and 0.3 gal. of water-gas tar and 0.6 gal. of coal tar applied per square yard. The cost of application was 5.8 cents per square yard for labor, tar 3.3 cents, gravel 1 cent, 2.6 cents for repairs, and 1 cent for removing waste material, making a total of 13.7 cents per square yard. An area of 417 sq. yd. was treated, 4 cu. yd. of gravel applied, and 3¾ cu. yd. of waste material removed.

Water-Gas Tar and Coal Tar, 9.—Since it was found that coal tar could not be applied satisfactorily when cold, it was thought that a mixture of coal tar and water-gas tar might be made which could be used without the trouble and expense of heating, and which at the same time would hold down a surface dressing better than water-gas tar alone, because of its greater body. A section of road, rough but free from holes, was selected for this experiment, and, after having been carefully swept, was treated with a mixture of equal parts water-gas tar and coal tar. This material was applied cold from the kettle in which it was made and a light covering of clean ½-in. trap screenings or pea stone spread on top. The mixture was not heavy enough to hold down as much dressing as should have been applied to bring the surface to a perfectly smooth condition, but when the road was well rolled a surface was formed which was fairly smooth and offered a good foothold for horses without increasing the resistance to traction of vehicles. The road was absolutely dustless when inspected three months later, and had worn somewhat smoother.

A section of roadway 560 ft. long and 15 ft. wide was treated with this mixture and 0.43 gal. applied per square yard. The cost of application for labor was 3 cents per square yard, tar 1.5 cents, screenings 0.7 cent, and for removing waste material 1 cent, making a total of 6.2 cents per square yard. An area of 933 sq. yd. was treated, 8 cu. yd. pea stone applied, and 8 2/5 cu. yd. of waste material removed from the gutters.

Water-gas Tar and Coal Tar, 10.—A slightly heavier mixture was applied in this experiment on the same kind of road and in the same manner as in experiment No. 9, with the exception that gravel was used instead of pea stone for a top dressing. Five parts of coal tar was used to three parts of water-gas tar, and 0.48 gal. was applied per square yard. The mixture, however, did not hold down the gravel well. As a result, the road was slightly dusty for some time and, although in better condition at the end of three months, did not present as good an appearance as No. 9, and the surface seemed to be rather porous.

A section of road 1,000 ft. long and 15 ft. wide was treated in this manner and the cost of application was 3.7 cents for labor, tar 1.7 cents, surface material 0.8 cent, and 1 cent for removing waste material, making a total of 7.2 cents per square yard. The area covered was 1,667 sq. yd., 12 cu. yd. of gravel was applied, and 15 cu. yd. of waste material removed.

Special Tar Mixture, 11.—A section of road, rough but free from holes, including a rather sharp curve, was selected for this experiment and, after being thoroughly swept, was treated with a mixture of water-gas tar, coal tar, rosin, and other substances applied at a temperature of 200° F, from a kettle in the same manner as in experiment No. 5. A rather heavy dressing of pea stone was then applied and rolled once or twice. A good asphalt-like surface was formed which was free from dust and which, at the end of three months, made a very favorable appearance in comparison with the other experiments. The surface was hard and resilient without offering the resistance to traction noticed on many of the other sections.

Two hundred feet of road 12 ft. wide was treated and 0.42 gal. applied per square yard. The cost of application was 4.6 cents for labor, tar mixture of 2.6 cents pea stone 1.7 cents and for removal of waste material 1.3 cents, making a total of 10.2 cents per square yard. An area of 267 sq. yd. was treated, 5½ cu. yd. of pea stone used and 2 2/5 cu. yd. of waste material removed.

Special Tar Preparation, 12.—A short section of road in such bad shape that resurfacing was necessary was selected for this experiment. The road was therefore first torn up with a steam roller fitted with spikes. A course of No. 2 stone was then spread on and rolled and followed by a course of pea stone, which was also thoroughly rolled. As the kettle could not be dragged across this road without tearing it up, the material, at a temperature of 218° F., was applied by means of coal hods and no attempt was made to broom it in. A large amount of the tar preparation was absorbed by the road and only a light course of pea stone was placed on top. The whole was then rolled for a short time and well consolidated. The road thus formed presented a fine appearance and was absolutely dustless. At the end of three months the appearance was still good, but a few rough and porous places existed, where the tar had gone through the surface and into the foundation. It was absolutely dustless, however. The treatment proved to be expensive and, unless very much better results follow than in the other experiments, it will prove too costly for general use.

A portion of road 75 ft. long and 12 ft. wide was treated in this manner and 1.5 gal. of the tar preparation applied per square yard. The cost of application was 14.8 cents for labor, 9 cents for material (reckoned at 6 cents per gallon), 3.3 cents for screenings, 3.3 cents for repairs (not including the pea stone), and 1.2 cents for removing waste material, which gives a total of 31.6 cents per square yard. One hundred square yards was covered, 4 cu. yd. of pea stone used, and 0.9 cu. yd. of waste material removed from the gutters.

Special Tar Preparation, 13.—A section of road free from holes but somewhat rough was selected for this experiment. Material similar to that used in experiment No. 12 was heated to 185° F. and applied to the road in the same manner as in experiment No. 5. The road had first been swept. A heavy covering of pea stone was then applied and rolled down. The surface formed was smooth and dustless, asphalt-like in appearance, and apparently waterproof. In very hot weather it was somewhat sticky in places, but this was doubtless due to the fact that more tar was used than was absolutely necessary. After three months it presented a smooth and even appearance and was dustless.

A section of road 490 ft. long and 15 ft. wide was treated in this experiment, and 0.67 gal. of the mixture was applied per square yard. The cost of application amounted to 5.8 cents for labor, 4 cents for tar mixture, 1.9 cents for pea stone, and 1 cent for removing waste material, giving a total of 12.7 cents per square yard. A total area of 817 sq. yd. was treated, 18½ cu. yd. of pea stone applied, and 7 2/5 cu. yd. of waste material removed.

Summary of Experiments with Tar Products.—In considering the tar experiments it will be noticed that in almost every case the cost for labor per square yard is high. This was largely due to the shortness of the sections treated, which made it impossible to handle large quantities of material at one time and prevented systematic routine work on the part of the laborers. Added to this, the cost of extensive repairs and of removing large quantities of waste material which had collected in the gutters, the total cost per square yard is in most case considerably in excess of what similar work could be done for under ordinary conditions.

Nearly all of the sections were in good condition when they were inspected in November. Some facts of interest have been noted which it may be well to mention at this point. It has been shown that water-gas tar is a satisfactory dust layer and preventive when used in moderate quantities on roads already in fairly good condition. It can undoubtedly be applied to the best advantage by means of an ordinary sprinkling cart on the unprepared road, and when used in this way serves to make the road surface firm and keep down the dust for some time at a very reasonable cost. Its odor is objectionable at first, but soon disappears. It must necessarily be applied more frequently than the heavier tars, owing to its lack of body. Where extensive repairs have to be made before treatment, it has but little value as a binder for the large, loose material, and whether its use even in large quantities will be satisfactory for this purpose and for holding down a heavy surface dressing is a matter for the future to decide.

At the present time some of the experiments with crude coal tar show up favorably in comparison with the work with special preparations, but time is needed to decide definitely upon their relative merits. As regards application, the special preparation has the advantage over crude coal tar in being less inflammable and less likely to boil over the sides of the kettle if heated too high, but, on the other hand, its cost is considerably greater. Two criticisms, which have already been offered by farmers to both of these products, are that the traction of heavily loaded wagons is increased and that in frosty weather the road is made very slippery and offers but little foothold to horses. While the mixtures of water-gas tar and coal tar, with a light dressing of trap screenings, give better results in these respects, it is impossible at the present time to say that their use will prove as satisfactory or economical in the long run. A material which can be applied cold is much easier to handle than one requiring heat, but of course the latter has the advantage of containing more binding material or base. Where surface dressing is needed the use of clean ½-in. screenings is certainly to be preferred to gravel, as less rolling is required and a better wearing surface is produced.

The surface treatment of roads with tar is more a palliative than a preventive of the dust nuisance. Some more permanent treatment of the road is essential for lasting results. It is the intention of the Office in the near future to carry on experiments along the latter line, with the use of a well-tarred sand to supply a part of the binding material and to fill the voids. One of the most promising methods with respect to cost which has suggested itself is to apply a layer of this tarred sand to the bottom course of No. 1 stones, which should first be well rolled. The second course of No. 2 stones should then be applied and the whole rolled until the sand has been thoroughly worked into both the upper and lower courses. A surface application of tar should then be put on and sufficient sand or fine stone chips spread to bring the surface to a smooth and uniform condition when rolled.

Oil Emulsions.—As there proved to be no convenient water supply at hand, it was found impossible to give these preparations a fair trial. As a quantity of material had, however, been donated for this purpose, it was used to the best advantage under existing conditions and in spite of many drawbacks gave fairly satisfactory results and indications of what might have been accomplished under more favorable circumstances. The materials used were specially prepared residual Texas oil emulsions. Both were capable of being mixed with water in all proportions. Upon examination, emulsion No. 1 was found to contain an asphalt-like base of 30 per cent and emulsion No. 2 a similar base of 57.5 per cent. They were mixed with water and applied from a sprinkling wagon on unswept road in fairly good condition.

Two applications of emulsion No. 1 were made twenty days apart. A 25 per cent mixture was used, the sprinkling cart traveling three times over the road during each application, once down each side and once over the middle. As the sprinkler covered about two-thirds of the width of the road, the center received about three times as much material as the sides. The preparation was well absorbed by the road, which assumed a somewhat darker color, and but little dust was noticed even at the end of three months. A thin coating of asphaltic base was retained by the road surface, which hardened upon drying, and undoubtedly tended to reduce the wear of traffic.

A section 700 ft. long and 15 ft. wide was treated in this manner, 0.19 gal. of the oil emulsion or 0.76 gal. of the solution being applied per square yard. Reckoned at 16 cents per gallon, the cost of application was 3.2 cents per square yard for material and 0.6 cent for labor, making a total of 3.8 cents per square yard.

Emulsion No. 2 was applied in the same manner as emulsion No. 1, but in this case only one application of a 23 per cent solution was made. The road thus treated had a somewhat darker appearance than that treated with the first emulsion. The general effects were similar and as the material sells at the same price as emulsion No. 1 its use proved more economical. It was, however, a little more difficult to handle and not as readily miscible with water.

A section 800 ft. long and 15 ft. wide was treated with this product and about 0.1 gal. of emulsion No. 2 or 0.4 gal. of solution was applied per square yard. The cost of application was 0.2 cent for labor and 1.5 cents for material, making a total of 1.7 cents per square yard.

The results obtained from the use of these materials may be compared with those from using water-gas tar, when light applications of the latter are made by sprinkling. Emulsion No. 2 has but little odor, while emulsion No. 1 has a rather strong though not exceedingly disagreeable odor, which, like that of water-gas tar, soon disappears. While the application of water-gas tar has the advantage of not being dependent upon a water supply, this special preparation, on the other hand, can be transported at a much lower rate, owing to its concentrated state.

An Investigation of Cylinder Oils.

The intelligent purchase of oil presents a difficult problem, one that demands the knowledge of the expert for a correct solution. Large buyers are more and more basing their orders upon technical determinations of the recognized constants by which the value of an oil may be determined. The following actual case is suggestive of the possible savings attainable through such methods. The management of a combination of mills called in a chemist, Mr. Arthur D. Little, of Boston, to collect samples from the various plants, to determine their constants and indicate opportunities for decreasing the expenditures. In his report, he tabulates the cylinder oils as follows:

Oil.	Price.	Sp. Gr.	Flash.	Fire.	Cold Test.
A............	51 cts.	0.898	520 deg.	613 deg.	48 deg.
B............	51 “	0.903	523 “	621 “	48 “
C............	38 “	0.887	541 “	617 “	52 “
D............	46 “	0.899	500 “	590 “	45 “
E............	38 “	0.886	500 “	572 “	41 “
F............	38 “	0.883	511 “	555 “	30 “

Attention is called to the range in price, which is much greater than the actual difference in the oils themselves. Although the constants for A, B and C are very nearly alike, there is a difference of 13 cents per gallon in the price. The other samples are manifestly inferior, but all were straight petroleum products containing no acid. In contrast, Mr. Little gives in his report the following constants of a cylinder oil, which is being generally and satisfactorily used by some of the largest concerns in the country on similar service: Specific gravity, 0.890; flash, 533°; fire, 610°; cold, 37°. This, he asserts, is also a straight petroleum product free from acid, but it costs only 20 cents per gallon. Based upon the substitution of this oil for the various kinds used in the different mills covered by the report, Mr. Little shows his client a possible saving of nearly $1,000 per year on the item of cylinder oil alone.

Smoke Reports on eight different coals are being made by factory and large building owners in Indianapolis, Ind., in order to determine to what extent the various kinds and grades of coal are responsible for the smoke nuisance.

The Erection of the Towanda Bridge.

The double track bridge of the Lehigh Valley Railroad across the Susquehanna River at Towanda, Pa., has 13 deck spans with four lines of plate girders 10 ft. deep, and from about 110 to 130 ft. long over all. There are, in all, 56 main girders, weighing up to 60 tons each, skewed about 50 degrees with the piers on which they are seated, with pin bearings at a clear height of about 26 ft. above ordinary water level. Several of the spans are, in the middle of the bridge, on a tangent, and at both ends the remaining spans form chords of a 3½-deg. curve of the axis. The total weight of structural steel in the bridge is about 7,500,000 lb., and the general features of its design were described in The Engineering Record of Nov. 9, 1907.

Except that the spans were supported on a masonry substructure instead of steel towers, the bridge greatly resembles an ordinary viaduct, and was erected on the same principle by an overhead cantilever traveler, which eliminated the use of falsework, avoided any obstruction of the channel or danger from floods, and provided for the rapid and economical handling and unloading of the heavy girders. Since the traveler was required to handle loads much heavier than those generally imposed on a viaduct traveler, and to support their centers of gravity farther than usual from the traveler base, it required a special design, and some radical changes were made in its construction. A general description of the traveler and its operation was given in the previous article, and the details of its construction, the novel features of its equipment and operation, and the successive steps of the erection are here described.

Delivering Girder to the Traveler, Towanda Bridge.

The traveler has two riveted Pratt trusses about 148 ft. long over all, and 18 ft. deep and 23 ft. apart on centers. They have 21-ft. panels and one truss is advanced one panel length beyond the other to correspond with the skew of the piers. The top chords are connected by transverse girders seated on their top flanges at panel points, and by X-bracing between the girders. The bottom chords are not connected except by a single transverse girder at the outer end, thus leaving the space between them free to permit the handling of girders from the rear to the forward extremity. The bottom chords are, however, stiffened laterally at panel points by inside knee braces to the top transverse girders.

Both top and bottom chords are compression members made with pairs of channels latticed; the middle vertical posts at the fulcrum points are of the same construction, and all other members have I-shape cross sections made with two pairs of angles, back to back, latticed. The trusses are mounted on trucks which divide them into 63-ft. anchor arms and 84-ft. cantilever arms, thus giving them an overhang well beyond the center of gravity of the longest girder when carried out to position one span in advance of the completed structure.

At the panel points between the anchor and cantilever arms the lower chords are seated across the top flange of a skew box plate girder resting at each end on a truck, with 2 double flange wheels tandem, running on a track of about 19 ft. gauge, with its rails normally just inside the center lines of the outside permanent girders of the bridge. The rear end of each truss is carried on a single two-wheel truck at the first panel point.

Vertical anchor rods pass through the rear trucks, and are connected at their upper ends by two pins at right angles to each other, with the end panel points of the lower chords, and at their lower ends have nut bearings on saddle pieces across the lower flanges of a skewed transverse reaction plate box girder suspended by them underneath the longitudinal girders of the bridge. The anchor rods are adjustable by sleeve nuts accessible from the upper ends, and can be readily disengaged from the transverse reaction girders to permit the latter to be moved around the piers.

When the traveler is advanced the reaction girders are lifted above track level to pass over the piers, and to provide for this movement, a clear space of 2 ft. wide is left each side of the bridge axis between the ends of the ties carrying the traveler track rails. These ties and rails are for special temporary service in erection only, and as soon as this is completed are replaced by the permanent ties and rails for the regular traffic service.

In order to clear the rivet heads in the top flanges of the longitudinal girders the 8 x 12-in. ties, 14 in. apart, are seated on wooden filler strip about 3 in. thick at the center of the span and 4 in. thick at the end, to correspond with the difference in the cover plates, that are set on the center line of the girders between the rows of rivets.

At the forward ends of the longitudinal girders, where the traveler fulcrums, the track ties for each rail are replaced, for about 8 ft., by a set of eight 8-in. transverse I-beams 8½ ft. long, supporting the track rails on 6 x 8-in. longitudinal sills. On each side of each rail there is a pair of 12-in. channels 7 ft. long riveted to their top flanges, with clearance between their webs for the truck wheels. This arrangement provides for the proper distribution of the weight of the traveler, and its load on the longitudinal girders, and affords a base for wedging the traveler truck up from the longitudinal channels, thus lifting it slightly to release the wheels and provide a fixed bearing for its fulcrum when in service handling the heavy girders.

All of the skewed transverse girders resting on the top chords at panel points have vertical posts 4 ft. each side of the bridge axis, which are riveted to the double webs of the girders, and project 4 ft. below their bottom flanges to carry longitudinal 20-in. I-beams forming the runway girders for a trolley track used in transferring the permanent girders from the cars to their position in advance of the finished structure. The transverse girders at the first and second panel points at both ends of the traveler have their vertical posts continued 6 ft. above the top flanges to carry upper lifting beams which support 30-ton wire rope tackles for lifting and lowering the 60-ton girders.

The runway girders support a trolley or transfer carriage 15 ft. long, with a frame made of longitudinal and transverse 12-in. channels with vertical webs, and fastened together with web connection angles and with horizontal gusset plates on their top and bottom flanges. There are eight 12-in. double flange wheels mounted on four full-length 3½-in. axles. Between each pair of axles is the double-web end strut of the carriage frame, which also acts as a transverse girder, from the center of which there is suspended a pin-connected vertical post supporting one end of a horizontal lifting girder in the axis of the bridge, which is connected to it by a 3½-in. pin through a round hole in the vertical suspender, and through a vertical slotted hole in the connection plate of the lifting girder.

The lifting girder is made with a pair of 15-in. channels 23 ft. long, latticed together 11½ in. apart, back to back, and suspended from the carriage at points 6 ft. each side of the center, where the webs are bored on the center line for 3½-in. connection pins, receiving U-plates 7 in. wide and 9-16-in. thick, with their lower ends bored for 2¾-in. longitudinal pins, which engage the upper ends of pairs of 20-ton hooks.

The hooks are made with 6 x ½-in. forged plates, with the jaws fitted to engage the top flange of the girder, and notched to clear the rivet heads there, thus locking them in position and preventing possibility of slipping. Two more pairs of similar hooks are provided at the extremities of the lifting girder, where their connecting pins also engage the jaws of vertical clevices which project above the top flanges of the girder and receive short eye-bolts 2¾ in. in diameter, pin-connected to pairs of ¾-in. triangular connection plates. The two projecting corners of these plates are bored for 3¼-in. horizontal transverse pins, the upper one being intended to receive the 30-ton tackle, and the lower one being provided with a shackle and cast-iron saddle, affording connection for a Manila tackle attached in a diagonal direction to use for fleeting the girders to position.

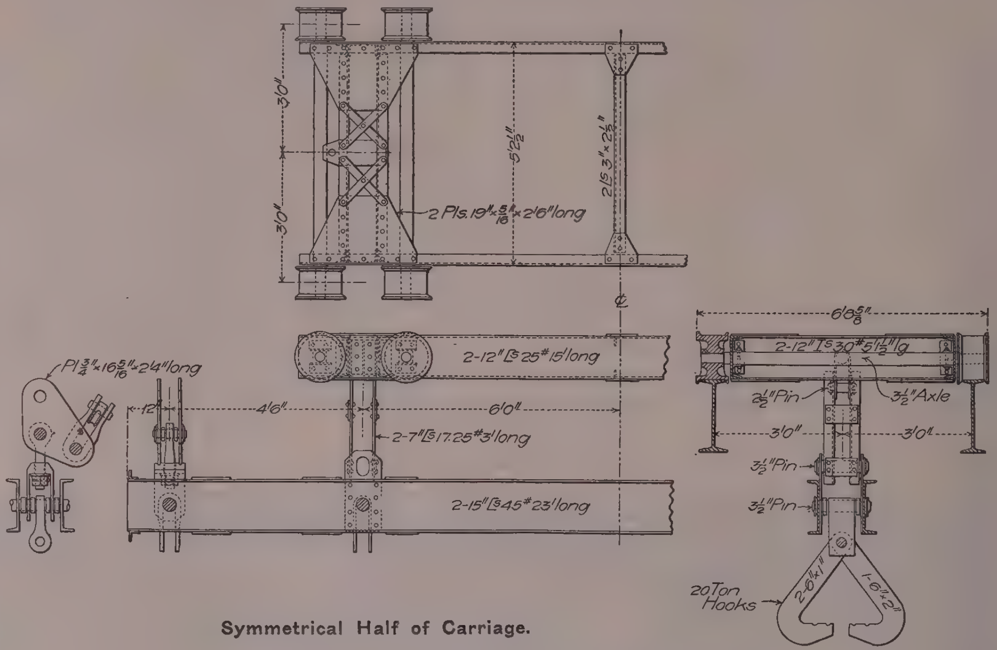
The two transverse skew girders at the rear end of the traveler support longitudinal timbers covered with 3 x 12-in. planks, making a floor for two four-spool hoisting engines, coal, water and other supplies. A 1¾-in. manila rope is attached to each end of the carriage, and led to a vertical sheave in the center of the end transverse skewed top chord girder, and thence back to the hoisting engine, thus affording positive means for moving the carriage in either direction. Sheaves, snatch blocks and tackle connections are provided at various points in the top chords and transverse struts, as indicated by the general plan, so that all lines may be carried over the top chords of the traveler and insure the proper operation of the carriage and hoisting tackles in any position, and always lead the lines clear of the girders to the different spools of the hoisting engine.

The traveler was erected on the fill at the end of the bridge, the carriage was moved back to the rear end of its runway, and the traveler was moved forward by two pairs of six-part tackles operated by a hoisting engine, until the front wheels were over the abutment back wall. The extremity of the overhang was supported on temporary falsework provided, because, in this position, there was no girder underneath the rear end to receive its anchorage, and it was not considered desirable to provide for the upward reaction by counterweighting.

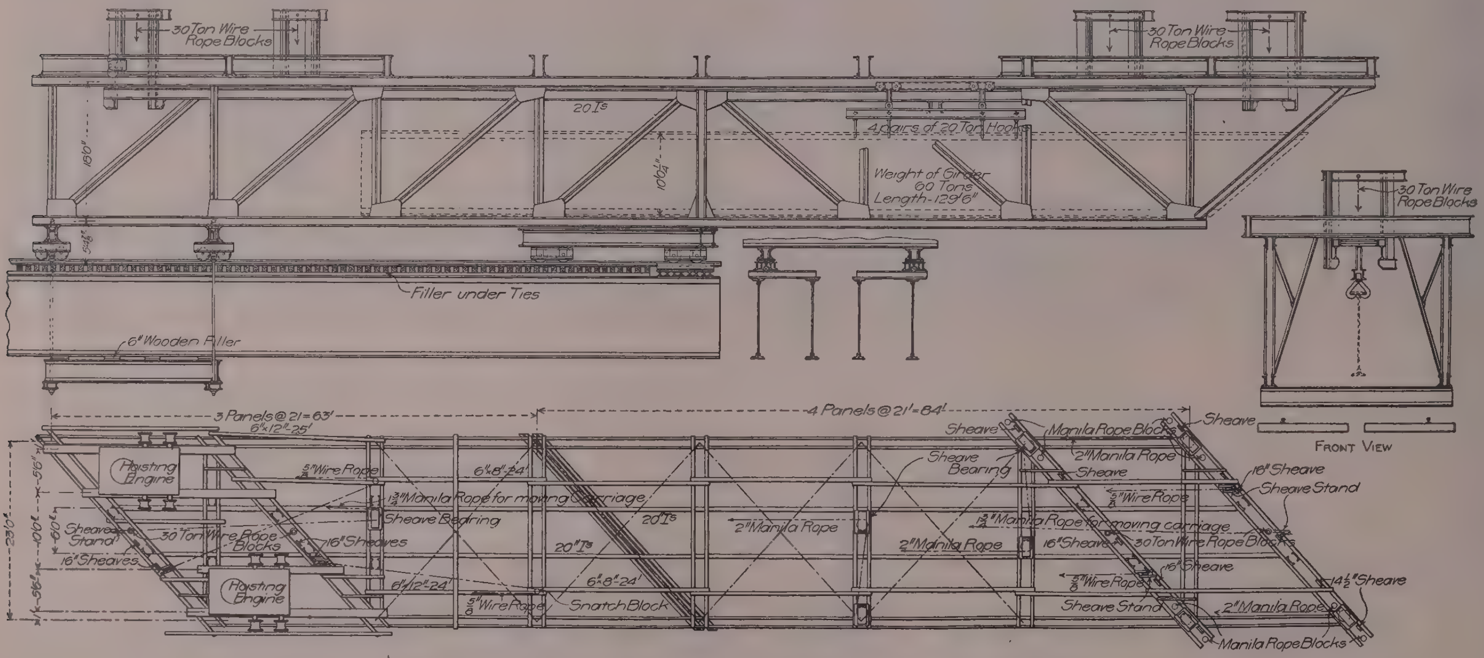
An outside girder was delivered on flat cars to a position between the traveler trusses with its center point in the axis of the bridge in the center of the first complete panel of the traveler. The 23-ft. lifting girder was suspended from the overhead lifting beams in the rear of the traveler by two 30-ton tackles attached to the triangular connection plates at its extremities, and was lowered over the girder until its four pairs of 20-ton hooks engaged the top flange of the girder. The hooks were carefully adjusted, and the 30-ton tackles were operated by the hoisting engines on the upper deck of the traveler, lifting the girder free of the cars and raising the 23-ft. lifting girder until its slotted holes registered with the round holes in the bottom of the vertical posts projecting below the lower flanges of the carriage. Pins were then inserted through these holes locking the lifting girder to the carriage, and the 30-ton tackles were slacked off and released, leaving the main girder suspended from the carriage.

The carriage was then pulled to the forward end of the overhang of the traveler by its 1¾-in. manila traversing line led around the sheave at the outer end of the overhang. Two 30-ton wire rope tackles suspended from the overhead lifting beams at the extremity of the overhang, with their fall lines led back to the hoisting engine, were attached to the triangular connection plates at the ends of the 23-ft. lifting girder, and were operated sufficiently to take the weight of the latter and its suspended main girder, thus relieving the pressure on the pins in the slotted hole connections between the carriage and lifting girders.

These pins were removed, and the 30-ton tackles slacked, lowering the main girder almost to its final elevation. Two pairs of manila tackles were attached to the triangular connection plates at the ends of the lifting girder, and with 130-ton tackle the girder was fleeted to its required position and lowered to bearing on the pier and abutments. The other three girders of this span were erected in the same manner, braced together, and the traveler track laid on them out to the first pier, preparatory to placing the girders of the next span.



Symmetrical Half of Carriage.



Traveler Anchored to Viaduct and Supporting Girder from Overhang.

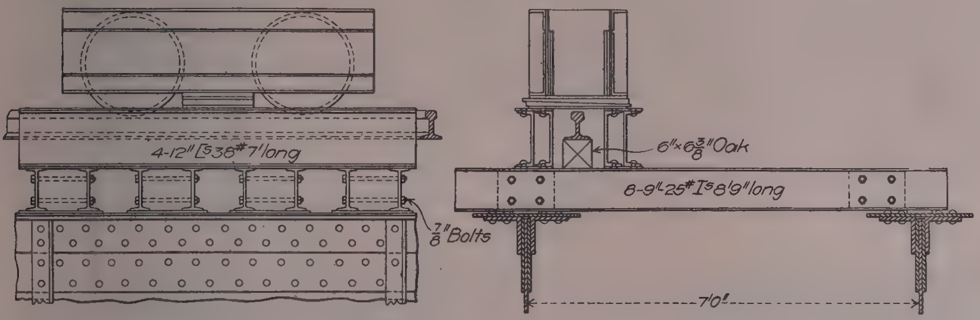
The carriage was moved back to the rear end of the traveler, the temporary falsework under the overhang was removed, the traveler was advanced until the forward trucks were over the first pier, and were wedged up as previously described, lifting the wheels clear of the track and providing a fixed support for the fulcrum. The rear trucks were anchored to the longitudinal girders of the first span, and the permanent longitudinal girders of the second span, with their end bearings attached to them, were unloaded from the cars, moved out to position and erected in the same manner as those for the first span had been handled. The succeeding spans were erected in the same manner, and the work was thus executed rapidly and satisfactorily with a comparatively small force.

The superstructure was built and erected by the Phoenix Bridge Company, Mr. John Sterling Deans, chief engineer; Mr. G. A. Tretter, and Mr. A. B. Milliken, respectively, engineer and superintendent of erection.

A Survey of the Forest Lands in the state of Illinois is to be made jointly by the State Laboratory of Natural History and the United States Forest Survey, the two contributing equally to the expenses of the work.

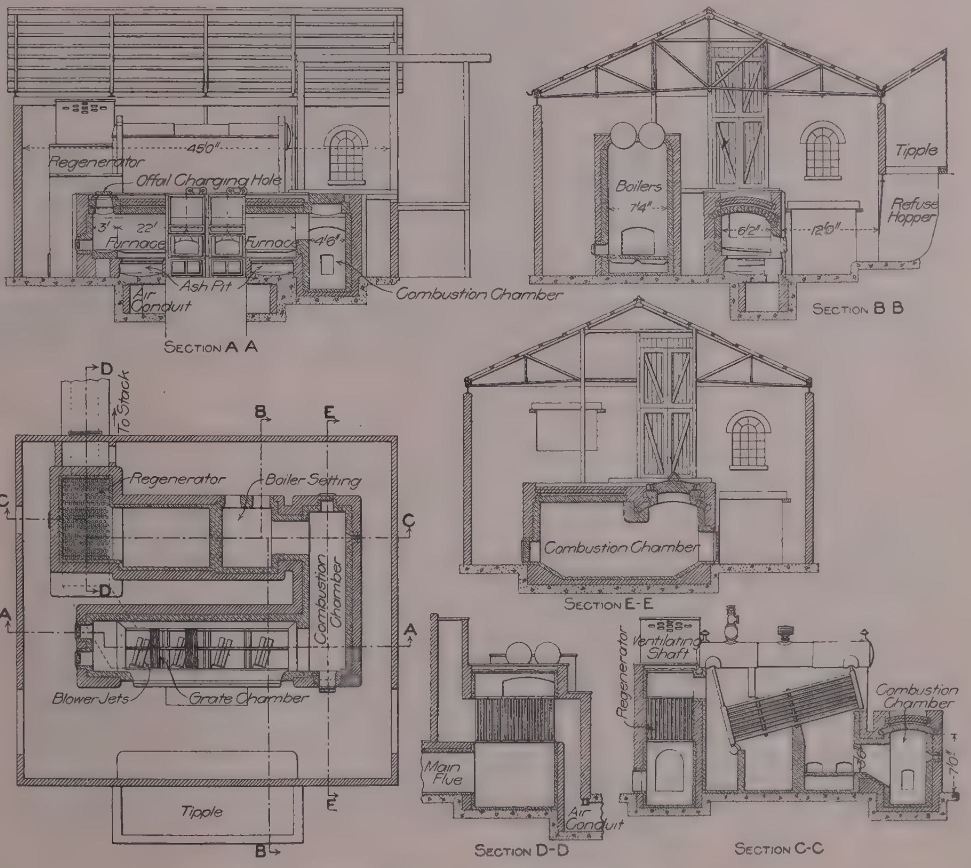
A 60-Ton Refuse Destructor in Seattle, Washington.

The city of Seattle, Wash., placed in operation, on February 1, last, a Meldrum refuse destructor, which is designed to cremate each twenty-four hours 60 tons of the municipal wastes normally collected in that city. Before a decision was made to adopt this method of disposal, and to build this destructor a careful investigation of the existing methods of refuse collection in the city, of the character of this refuse, and of the most satisfactory means of disposing of the latter was conducted. Mr. R. H. Thomson, city engineer of Seattle, visited a plant of practically every type for garbage reduction, waste incineration, and refuse destruction in this country, and then inspected many similar installations in England, Scotland, and Germany. The following conclusions are abstracted from an exhaustive report by Mr. Thomson on the results of this extended investigation.



Wedging Base for Erection Loads, Towanda Bridge.

Three different methods of the disposal of the municipal wastes were considered by the report to be entirely distinct. First, a refuse destructor was held to be a plant in which it was possible to cremate without the use of auxiliary fuel all animal and vegetable matters, including household waste, as well as ashes, yard, street and store sweepings, and stable and slaughter-house offal—in short, a means by which all municipal waste is destroyed. In referring to what is generally designated as a waste destructor, reference was made to that class of destructors which receive papers, rags, bottles, and other materials of similar character, to be assorted and distributed, with provisions for incinerating the combustible materials. The garbage reduction works were considered as a class which in some manner reduce to grease and other by-products, all animal and vegetable refuse of the table, of establishments of food dealers, and of slaughter-houses.



Details of Seattle Refuse Destructor.

From the conditions as Mr. Thomson found them in the various municipalities in this country and abroad, he considers that up to that time, despite all the attention given to the matter, it is clear that no substantial financial return had been made in more than a very few places by the use of the reduction method. In these places, also, such return was obtained only by the private company operating the works, and at an equal, if not greater, expense to the municipality than if such matter had been destroyed. This expense has resulted, in part, from the fact that where garbage reduction is used, three classes of collection and disposal are necessary, thus greatly increasing the cost of haul, which in any case is very burdensome. The highest returns from the garbage-reduction method appear to have been made in cities where a complete sewerage system does not exist, and where it is necessary to maintain the swill barrel. There is, however, one source of considerable profit in the reduction process, Mr. Thomson considers, and that is with reference to the by-products to be obtained from the reduction of dead animals. Under all the existing circumstances, therefore, the report unhesitatingly recommended to the city of Seattle the erection of a destructor plant rather than reduction works. At some time it was held, nevertheless, that reduction works may profitably be operated in connection with the destructor plants it is proposed to provide.

Based on the results of the investigation of the existing conditions in Seattle, and of the results obtained with destructors of different types, the decision was made to build a destructor which would have a capacity of destroying about one-fifth of the total average daily production of municipal wastes. Before the present destructor was placed in operation, the municipal wastes collected, amounting to about 200 tons daily, were hauled to the public dump on the tide flats about one mile south of the central business district of the city. The collection of these wastes is made entirely by private contractors, who obtain customers along the definite routes much the same as milk and laundry delivery routes are established. The average householder is charged from 25 to 50 cents per collection for the removal of the wastes from his premises, collections being made in the residential districts on the average of about once a week. Scaled upward from these mimimum rates various prices are charged, which prices depend largely on the amount of materials to be removed, hotels, restaurants, and similar places of business being assessed as high as $25 per month. Such large producers of waste receive, however, a collection every day.

The character of the wastes collected by these private contractors may be best illustrated by the materials delivered to the destructor during the first month of operation of the latter. In volume, 16.5 per cent. of the total delivered was garbage, including table wastes, refuse from dealers in food-stuffs and similar materials; 10.3 per cent. was stable manure; 56.2 per cent. was rubbish, which was comprised of paper, light wooden boxes, tin cans, rags and other refuse of a similar character; and the remaining 17 per cent. of the volume was ashes. By weight, 30.2 per cent. of the materials delivered was garbage; 12.5 per cent. was manure; 22.8 per cent. rubbish; and 34.5 per cent. ashes. From this analysis it may be seen that the refuse to be destroyed includes practically all kinds of municipal wastes. It is also evident that the percentage of garbage is comparatively small, due to the fact that much of the garbage is burned in the kitchen range, especially in outlying districts.

It has been estimated that not less than $300,000 per year is paid individually by the citizens of Seattle to private scavengers. Owing to the uncertainty of a place of deposit of the wastes collected, and to the great length of haul, it is probable that this expense is double what it would be if there were convenient places of disposal. Such places of disposal can, under the existing circumstances, be had only at destructors. Each destructor, such as one of those required to provide sufficient present capacity, would cost, exclusive of the site, at least $50,000. At the same time, no information concerning the results of destroying the refuse collected in Seattle was available when the decision was made to burn the wastes. On account of the limited amount of money appropriated to erect a destructor, and because it was deemed especially desirable to determine the best type of the latter to be adopted, the 60-ton plant was built, with the idea of subjecting it to thorough tests in operation to determine its adaptability to the existing conditions.

This destructor could fortunately be located exactly at the geographical center of the city, on reclaimed land at the edge of Lake Union, a large body of fresh water within the city limits, where sufficient space for disposing of the clinker for some years to come is available. This first destructor is proposed to serve eventually an area within a radius of about a mile. Later, if the disposal of the municipal waste by destruction is found to be the most satisfactory method, other destructors will be erected at various points throughout the city, so as to reduce the haul from all sections to the most economical limit.

The destructor that has been built is in a building 42 x 45 ft. in plan, which has galvanized-iron sides and roof carried by a timber frame. This building was erected with the idea that later it might be replaced, if necessary, by a permanent structure, in case the operation of the destructor was successful. A tipple is placed in a wide, elevated platform at one side of the building, from which the refuse may be dumped directly into the latter. This platform is reached by means of a long timber trestle approach on easy grades. Platform scales are placed at the head of this approach, in order that each wagon load of material delivered to the destructor may be carefully weighed. A hopper leading from the tipple to the firing floor in the building provides considerable storage space for refuse, and the platform around the tipple is wide enough to permit additional quantities of refuse to be stored there.

Tipple, Showing Character of Refuse.

Refuse Destructor from the Rear.

The destructor is of the regular Meldrum continuous-grate type, with four separate ash-pits. The details of the construction of this destructor are shown in the accompanying illustrations. The grates are placed in a chamber 6 ft. 2 in. wide x 6 ft. 10.5 in. high, this height including the ash-pits, and with a total length of 20 ft. The gases from the grate chamber are delivered at one end of the latter to a combustion chamber, the axes of these two chambers being at right angles. The combustion chamber has a total length of 20 ft. and is 4.5 ft. wide, with a maximum height of 9 ft. The bottom of this chamber is depressed from both ends toward the transverse center line, to provide for the collection of dust. At the opposite end of the combustion chamber from the continuous grate chamber is a 220-h.p. Babcock & Wilcox water-tube boiler in a standard brick setting for boilers of that type. The long axis of this boiler setting is parallel with the long axis of the grate chamber and is on the same side of the combustion chamber as is the grate chamber. At the outlet end of the boiler setting a brick chamber, 5 x 10 ft. in cross section, is built in a flue connection to a stack outside of the building to enclose a nest of 264 2.5-in. vertical tubes, 5 ft. long. The gases from the furnace pass through these tubes on their way to the stack, and the air supply for the grate chamber is passed around the tubes before being admitted to the grate chamber. An underground conduit connects this regenerator chamber with a space under the ash-pits of the grate chamber.

The firing floor at the base of the hopper, into which the materials are dumped from the tipple, is on the side of the grate chamber opposite from the boiler setting. The materials are fired from this floor to the grates by hand, through four counter-balanced doors, in openings in the side of the grate chamber. Three firemen and two trimmers are at present employed on the firing floor, but it is expected to be able to eliminate one fireman. The ash-pit under the grate is divided into four compartments by partition walls transverse to the long axis of the chamber. Access to each of the separate pits is obtained through two doors immediately under the firing doors in the side of the grate chamber. The doors are constructed so as to seal the pits and render the latter air-tight when they are closed. The air necessary for combustion is supplied entirely from the air heater or regenerator in the chamber at the end of the boiler setting. Two steam jet blowers in each ash-pit deliver this heated air through the grates under forced draft. These blowers are supplied with steam from a connection with the boiler and are under the immediate control of the firemen. The amount of draft supplied to the grates is thus capable of complete regulation. At the same time, the forced-draft system, in connection with the heated air from the regenerator, raises the temperature of combustion as much as 250 degrees Fahr., as compared with the temperature obtainable without this method of firing. The regenerator also precludes the necessity of a drying hearth, such as is frequently used to very rapidly evaporate moisture in the refuse. The value of the heated air supplied to the grate chamber is unquestionably very great in starting the combustion of the refuse.

At the end of the grate chamber, opposite from the connection of the latter to the combustion chamber, is a man-hole in the top of the chamber, through which heavy offal, such as butchers' wastes and manure, may be charged. An approach is made to this man-hole at the level of the platform around the tipple, in order that the charging may be done readily. The location of the hearth on which objectionable offal is thus discharged without handling is such that the noxious gases distilled on this hearth must pass over the entire grate area and finally through the grate chamber. In the end of the combustion chamber, at the connection of the latter with the grate chamber, a space is provided for the cremation of carcasses of animals. A crane runway will be installed in the roof of the building, so carcasses may be delivered from the approach to the tipple to a charging opening in the top of this cremating chamber. The combustion chamber is in a position in relation to the grate chamber such that the entire volume of high-temperature gases must pass through it. For this reason the end of the combustion chamber is considered to be perfectly adapted for the rapid and efficient cremation of large carcasses without nuisance.

The combustion chamber is designed to trap the major part of the dust passing over the grates and is said to secure retention of over 75 per cent. of the dust within the grate chamber. This dust may be removed conveniently through an opening in both ends of the combustion chamber, which openings are normally closed with air-tight doors.

The gases passing from the grate chamber through the combustion chamber are admitted from the latter to the setting of the boiler at the front of the latter, at the usual opening for fire doors at the front of the setting. Firing doors are also placed in the side of the boiler furnace, in order that auxiliary fuel may be used for firing in case power in addition to that generated by gases from the destructor is desired. Such fuel has not, however, been utilized thus far, as no equipment has been installed to operate on the steam produced, except a boiler feed pump. The steam jet blowers under the grates are said to require about 15 per cent. of the steam generated by the boilers. At present the remainder of the steam produced is permitted to be blown to waste.

The gases after passing through the tubes of the boiler are blown downward through the tubes of the regenerator in the chamber at the end of the boiler setting and thence to the flue connection leading to the stack outside of the building. The cold-air inlet of the regenerator chamber is arranged to draw the entire supply for the destructor from the interior of the building by a system of downward exhaust. In this manner the atmosphere of the building is kept comparatively clean and pure. Any dust reaching the regenerator is trapped in the pit immediately under the latter, from which pit it can be readily removed at any time.

The main flue leading from the base of the regenerator chamber to the stack has a cross-section 3.5 ft. wide by 5 ft. high and is 20 ft. long. The stack is of reinforced concrete, 6 ft. in diameter and 81 ft. high, and was built by the Weber Concrete Chimney Co., of Chicago. A door is placed in the flue connection to the stack, close to the latter, in order that any dust reaching the flue may be removed, although this quantity of dust has been found to be very small.

At the time these notes were prepared the destructor had been in operation just two months. During the first two weeks of the first month it was operated with a single 8-hr. shift; two 8-hr. shifts were used the third week of that month, and since then the destructor has been in continuous operation with three 8-hr. shifts. Since the inception of operation the destructor has consumed in 24 hours as high as 60 tons of the material delivered to it, without the addition of any auxiliary fuel whatever, and with no apparent odors and practically no smoke from the stack. The character of the materials consumed has been approximately the same from the start. The physical analysis of the materials received during the month of February has already been stated and is indicative of the refuse handled daily.

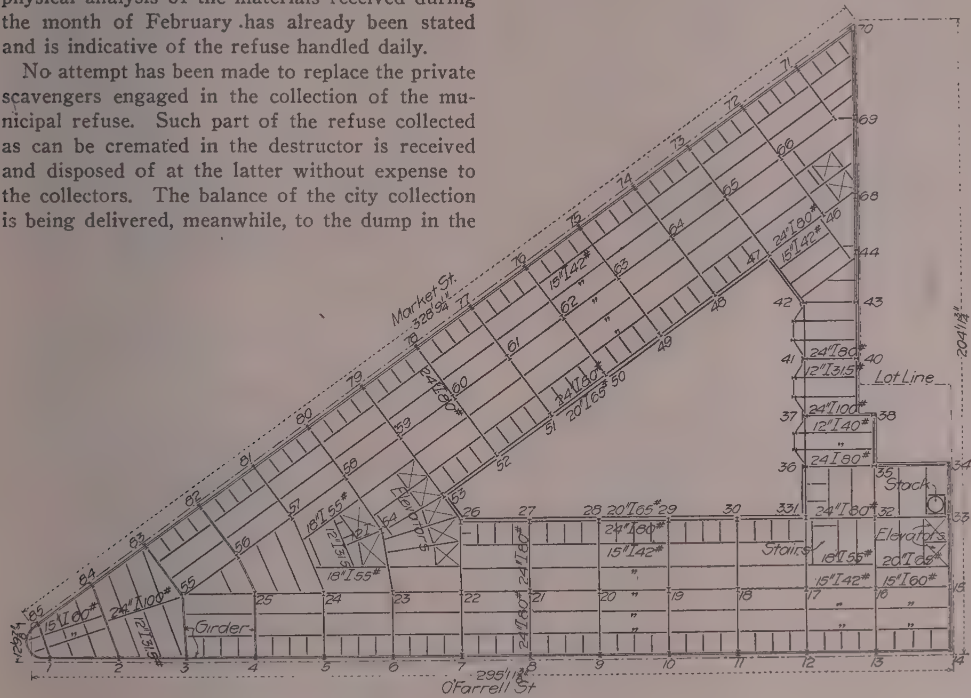
No attempt has been made to replace the private scavengers engaged in the collection of the municipal refuse. Such part of the refuse collected as can be cremated in the destructor is received and disposed of at the latter without expense to the collectors. The balance of the city collection is being delivered, meanwhile, to the dump in the tide flats south of the business section of the city, until the results of operating the destructor over a sufficient length of time have been obtained to justify the decision to erect additional destructors to serve the entire city. During this period of trial, which will probably extend over at least a year, a most thorough and exhaustive study will be made of the materials delivered to the destructor and of the results obtained in the operation of the latter. The character of the gases in the differnt parts of the destructor, the temperature of these gases at the various points, the amount of air supplied under the grates and similar operating conditions are observed daily by one of the regular city chemists. The amount of water evaporated in the boiler will be carefully measured daily, and the quantity of steam blown to waste closely observed. From these measurements and observations it will then be possible to determine the amount of steam required by the blowers and also whether a sufficient quantity of steam is produced to justify the installation of apparatus to be operated by it.

The destructor was designed by Messrs. Meldrum Bros., of Manchester, England, and was installed under the direction of Mr. Wm. Mortimore, as engineer for that company. The design and installation of the destructor were made and the operation is under the supervision of Mr. R. H. Thomson, city engineer of Seattle. Mr. C. J. Moore, as assistant engineer, represented the city during the installation and is in immediate charge of the operation of the destructor.

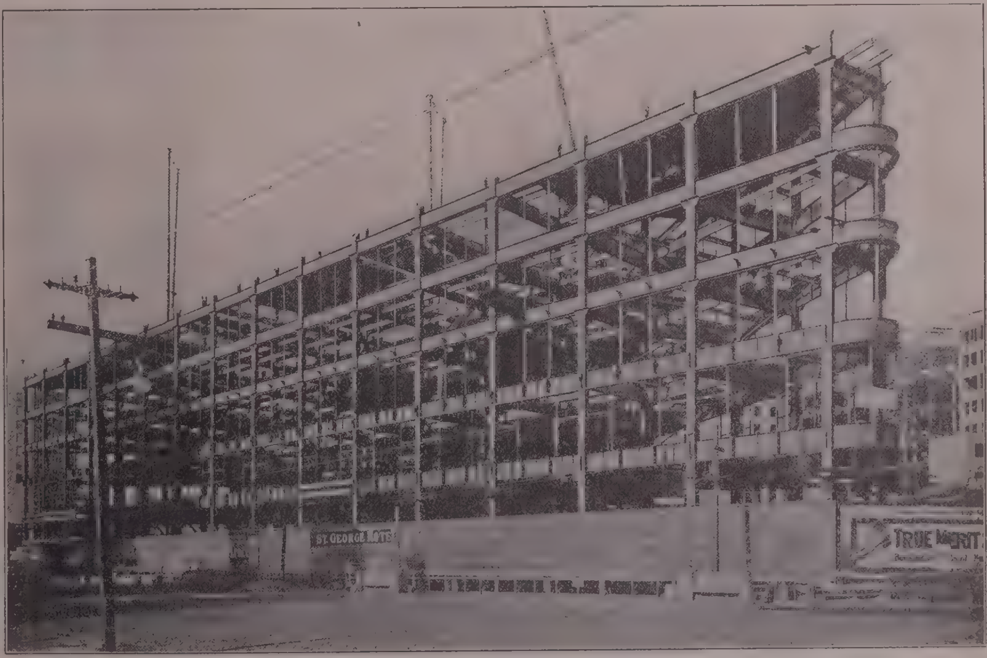
Road Maintenance in Worcestershire County, England, cost about $333 per mile for the year ending March, 1907, according to the annual report of the County Council. The total mileage was 468½ miles, and the number of inhabitants of the county 455,000. Great complaint is made against the heavy wear caused by traction engines and automobiles.

The Phelan Building Floor Construction.

The beam plans and general details of the eleven-story framework are very much complicated by the irregularity of the lot, which is so great that many of the lines of columns are not continuous; many oblique angles are necessitated and it was impossible to construct the building symmetrically. The arrangement of columns and the general system of beams and girders is shown by the plan of the fifth and sixth floors, which is typical of all floors from the first to the eleventh, inclusive. In the third story the size of the light court is very much diminished, and in the second it disappears altogether, requiring in the first and second floors an unusually intricate arrangement of beams and girders in the center of the building.



Fifth and Sixth Floor Framing Plan, Phelan Building.



View of Phelan Building Six Weeks after Commencement of Erection.

The design of the steel framework throughout involves an unusual number of difficult features, and was facilitated in an exceptional degree by the consideration of the architect, who took great pains to work in harmony with the designers of the structural steel and determine some of the architectural requirements to conform to those of the steel work, as, for instance, in the location of columns 54-91-90-37, which were allowed to be placed, within limits, in the positions most advantageous for simple and satisfactory details. In the same way some of the most difficult girders, such as 26-53, 28-91, 91-90, were also arranged to suit the structural requirements and the walls located to correspond.

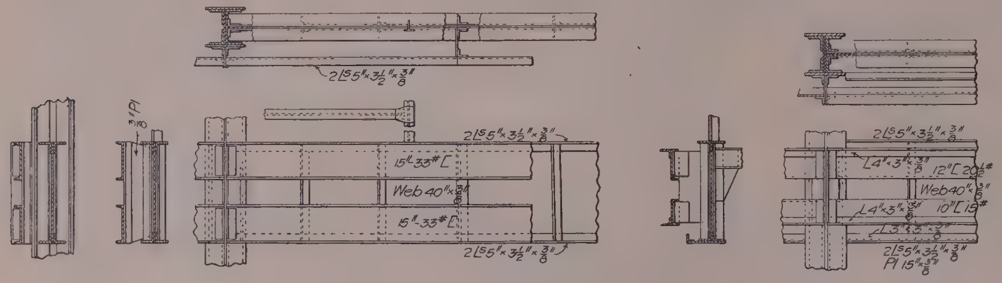
This collaboration was highly appreciated by the structural steel designers, and very much promoted the economy and rapidity of the work and its satisfactory execution, as well as the excellence of construction and harmony of parts. The advantages thus secured were indicated by the drawing-room verdict that it was "the straightest crooked job ever turned out." Actual proof of advantages gained is found in the fact that the cost of detailing and drawing was reduced to or below that of ordinary straight construction, and that the work was erected with rapidity and without difficulty or any unusual charge for field alterations or shop mistakes.

The architectural designs and details were made in the San Francisco office of the architect, Mr. Wm. Curlett, and the structural steel work was detailed in the Ambridge office of the American Bridge Co., near Pittsburg, over 3,000 miles away. Ordinarily, such a division of work results in very great delay on account of the necessity for transmitting sketches back and forth across the continent to be submitted and approved thus requiring at least three trips, and two or three weeks time for every successive question which cannot be asked and answered by telegraph.

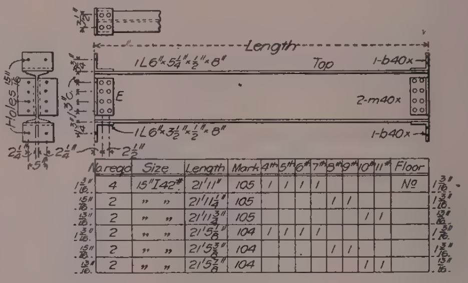
In this case Mr. Paul L. Wolfel, consulting engineer of the American Bridge Co., remained at the outset a number of weeks in the architect's office in San Francisco, assisting there in the preparation of the general plans and standard details in accordance with which the architectural details were worked out in San Francisco. All important questions were thus settled so completely and definitely in the beginning that the subsequent correspondence was confined to very short letters and the design and fabrication of the 6,000 tons of complicated steel work was completed in less than eight months, in accordance with the following calendar: First information received, Feb. 21, 1907; final information received March 19; first material ordered

Feb. 21; final material ordered April 6; first drawings issued to shop March 18; final drawings July 11; first material shipped April 5; last material shipped Oct. 2.

The rapidity and economy of drawing-room work was very much promoted by the use of the system of standard details previously adopted by the American Bridge Co. At the beginning of this work a set of standard details suitable for the connections of most of the beams, girders and columns was prepared, and each of them designated by a reference letter. Wherever these details were applicable in the framework, the corresponding reference letter was marked on the general plan, and when the members involved were drawn, those dimensions were not repeated, but were merely indicated by reference to the standard, the general dimensions and information specific to the members aside from its connections were put on the drawing and the latter, when completed, was marked with the reference letter appropriate for each standard splice plate, connection angle, or other element, with a pier number and a cross indicating that it was of standard construction. This diagram, together with a blueprint book of standards required on the job, gave sufficient data for all shop work and provided it in a very simple and efficient form for quick reference.

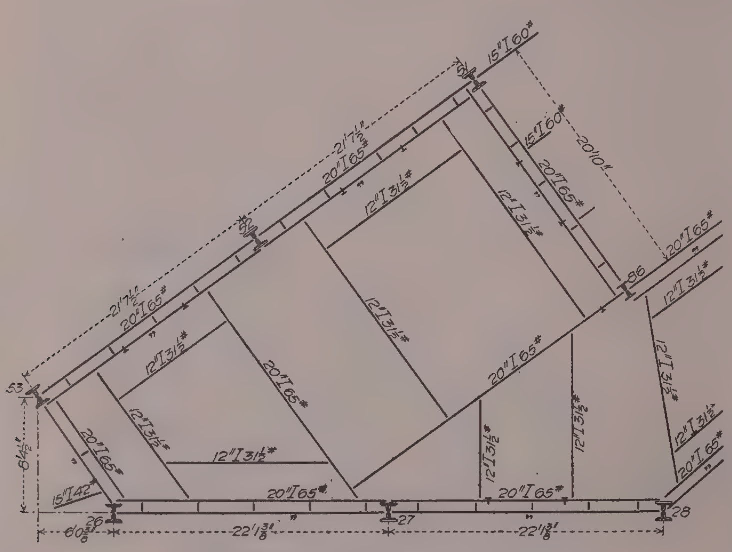


Second Floor Spandrel Girders on Market and O'Farrell Streets.

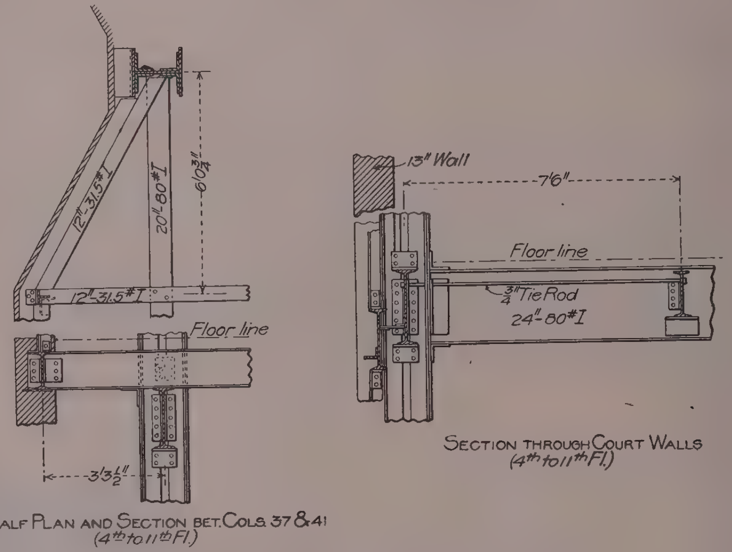


No. reqd	Size	Length	Mark	4th	5th	6th	7th	8th	9th	10th	11th	Floor
4	15"I42#	21'11"	105	1	1	1	1					No
2	" "	21'11¼"	105					1	1			
2	" "	21'11¾"	105							1	1	
2	" "	21'5⅛"	104	1	1	1	1					
2	" "	21'5⅜"	104					1	1			
2	" "	21'5⅞"	104							1	1	

General Sketch and Order for Beams.



Second Floor Framing for Light Court.



Half Plan and Section bet. Cols. 37 & 41 (4th to 11th Fl.)

Section through Court Walls (4th to 11th Fl.)

Typical Wall Supports in the Phelan Building.

All columns have I-shape cross sections and are made, as usual, in two-story lengths spliced 2 ft. above the floor level. All of them are made with four 6 x 6-in. flange angles and a 14-in. web plate throughout and vary only in the thickness of the metal and in the addition of 16-in. cover plates on the flanges for the lower story sections, thus retaining the same principal dimensions from top to bottom, although the cross sectional area changes from a minimum of 24½ sq. in. to a maximum of 132.25 sq. in., which is required for columns 2 and 84 in the narrow end of the building, which are proportioned for a maximum total stress of 1,266,000 lb.

All floors have reinforced concrete floor slabs proportioned for total loads of 175 lb. per square foot, and are carried on the top flanges of I-beams of varying lengths and depths, but largely composed of 15-in. 42-lb. beams about 7 ft. apart and 21 ft. long. The beams are, in general, parallel to Market and O'Farrell Sts., and are web-connected to the columns and intermediately to transverse girders generally consisting of single 24-in. and 18-in. I-beams. Plate girders are used for the transverse girders at the narrow end of the building in all floors and practically through the entire floor in the first and second stories.

The masonry of the outer walls is carried on plate girders at every story which in the two street fronts are concentrically connected to the column webs. On the third main side of the building these girders are concentrically connected to the flanges of the columns and have channels bracketed clear of the column faces which carry the exterior part of the wall. In all cases these girders carry their portions of the floor loads, as well as the wall loads. In all floors the panels adjacent to the wall girders have horizontal transverse tie rods connected to the girder webs about 5 ft. apart to give additional stiffness in resisting possible earthquake shock. Beam tiers which project beyond the outer face of the wall for cornices or belt courses have the tie rods replaced by 6-in. horizontal channels connected to the girder webs with deep gusset plates, securing a knee-brace effect which greatly increases the rigidity of the girders.

The walls of the interior court are supported on 20-in. I-beams with their webs braced by riveted connections to the adjacent floor beams and their top and bottom flanges connected by horizontal bracket angles to the columns. The floor panels adjacent to the light court, like those along the outer wall, are provided with horizontal tie rods engaging the girders near their upper ends.

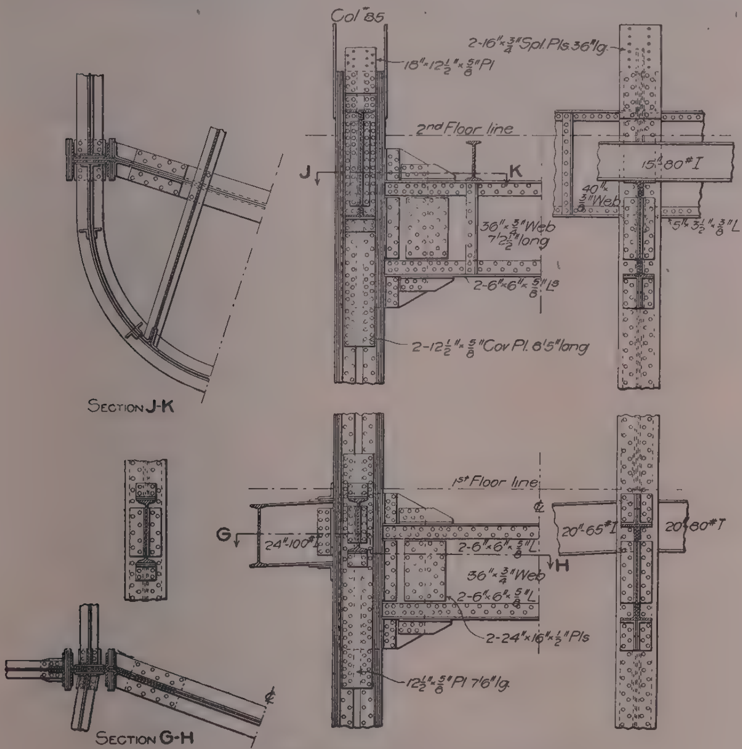
On one wall of the light court there are in each story three bay windows carried by the cantilever projections of 12-in. floor beams fulcrumed on the wall girders and web-connected at their extremities to fascia girders of the same depth which carry the 13-in. walls and the window framing.

In the second story the spandrel girders on the street front are made with 40 x ⅜-in. web plates and pairs of 5 x 3½ x ⅜-in. flange angles and are web-connected to the center lines of the column webs. They are about 22 ft. long, and at two intermediate points on the outer faces have vertical connection gusset plates connected to their web-stiffener angles and projecting far enough to receive an upper and a lower 15-in. channel with the flanges turned outward and the vertical web about 3 in. clear of the face of the column to which it is also connected by a similar gusset plate connected to the channel flange and field riveted between the end vertical angles on the channel web. This construction provides for a very heavy weight of wall masonry and a wide projecting belt course, which is an important feature of the architectural motive. The third story construction of the corresponding members is similar except that the offset channels are only 12 in. deep and that their flanges are turned inward. In this case also the channels are reinforced by flange angles riveted to their lower edges and the bottom flange of the girder has a projecting reinforcement plate with a stiffening angle on the outer edge.

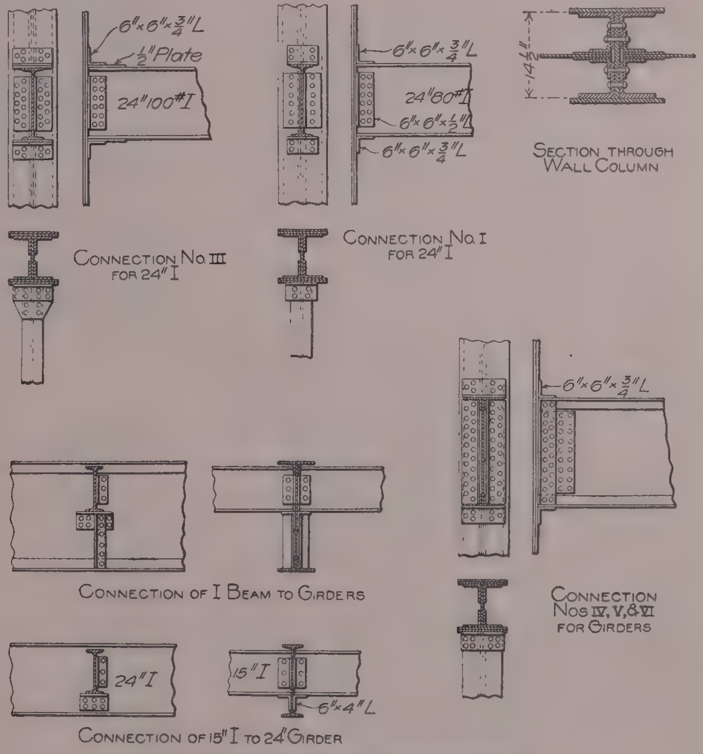
The curved wall at the narrow end of the building projects about 6 ft. beyond the centers of the last two columns and is carried by a curved plate girder with a 40 x ⅜-in. web and 5 x 3½ x ⅜-in. flange angles. The girders, which are about 18 ft. long in development, were shipped in single pieces and are web-connected to the column webs at the ends. Intermediately they are supported about 26 in. each side of the center line, by full-depth web connections made with double bent plates, to the extremities of 15-in. 80-lb. cantilever I-beams fulcrumed on the top flanges of transverse plate girders connecting the two end columns, as shown in the detail. In some of the upper floors, curved angles and connection plates project from the outer face of the curved girders to carry the belt courses and cornice projections, as indicated in the section at the 10th floor, and at the 11th floor there is a smaller curved girder outside the main girder and connected to it by vertical transverse gusset plates engaging the web stiffeners of both girders, as shown in the detail.

The transverse girders which serve as fulcrums for the cantilever girders supporting the curved girders connect the pairs of columns in the narrow end of the building and since they are oblique to the latter presented very difficult connections with them. The problem was solved by making connections somewhat similar to that of the floor beam in a railroad bridge. A short section of the column web is made with an increased width and projects through a slot left for that purpose in one of the flange cover plates and beyond the latter is bent into an angle of the transverse girder and stiffened by oblique angles shop-riveted to it and to the column flanges. Beyond these oblique angles a plate projects to form part of the web of the girder and is field riveted between the projecting ends of the flange angle which engage it and are continuous up to their intersection with the column. The column web and the main girder web are further connected by cover splice plates on both sides, which are field riveted, making a rigid connection that is still further stiffened by means of top and bottom flange angle splices field riveted to the projecting column web and to the girder flanges.

The anchor arms of the cantilever beams in the narrow end of the building are web connected to transverse girders connecting the second pair of columns and oblique to the latter like those previously described. The oblique connections between the column and girder are substantially like those already described except that the short flange connection angles are omitted.

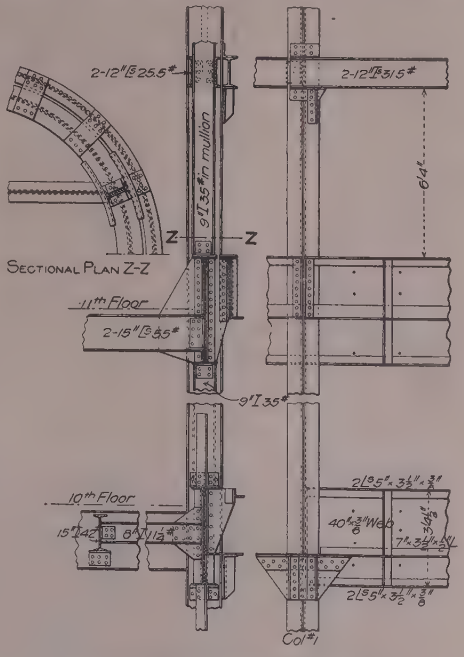


Oblique Girder Connection in End Panel.


6″×6″×¾″ L
½″ Plate
24″ 100# I
6″×6″×¾″ L
24″ 80# I
6″×6″×½″ L
6″×6″×¾″ L
14½″
Section through Wall Column
Connection No. III for 24″ I
Connection No. I for 24″ I
6″×6″×¾″ L
Connection of I Beam to Girders
Connection Nos. IV, V, & VI for Girders
24″ I
15″ I
6″×4″ L
Connection of 15″ I to 24″ Girder

Standard Beam and Girder Connections.

All standard connections are made with ¾-in. rivets in the beams and girders and ⅞-in rivets in the column, and are made with both vertical and horizontal field-riveted connection angles for webs and flanges, as shown in the standard connections. Where special rigidity is required it is attained by the insertion of a wide, horizontal plate between the top flange or the beam or girder and its upper horizontal connection angle to the column. The sheet of standard connections is supplemented by the blueprint book of standards, which has 47 pages of detail drawings and tabulations of all the separate plates and angles in the typical connection with their respective marks and varying lengths so that they can be selected by inspection and applied to the general diagrams, which are drawn of the different members. The convenience and simplicity of this system of drawing is indicated by the sample illustration for floor beams 104 and 105, while 16 pieces of different lengths are ordered from a single very small card.



Details of Rounded End Panel.

Mr. W. Curlett is the architect of the building, and the contractor for the structural steel was the American Bridge Co., Mr. Paul Wolfel, consulting engineer. The general contract was awarded to Mahony Brothers, who erected the steel work.

The Extension of the Government Railway in German Southwest Africa towards Keetmanshoop has been rendered difficult by the scarcity of water, which is brought in at a cost of six cents a quart. Great difficulty has also been experienced with labor, the only class able to stand the climate being the natives from the Cape districts.

Time Penalties on Government Contracts.

In The Engineering Record of April 4 some decisions were referred to as showing the importance of contractors maintaining a proper rate of speed in the execution of their work in order to avoid the infliction of the penalties or liquidated damages almost universally provided for in contracts for construction work for failure to complete within the stipulated time. A recent decision of the United States Court of Claims announced as late as April 13 instant emphasizes the correlative rule that the owner must do nothing to delay the contractor from beginning at the stipulated date or from continuing in its performance if he wishes to retain the right to impose the penalty for overtime in completion.

The case was that of Nicholas Ittner against the United States, the suit being for liquidated damages at the rate of $20 a day for 243 days overtime in completion, amounting to $4,860. The contract was signed by the contractor and a constructing quartermaster on April 4, 1903. It provided that work should commence on or before April 6, 1903, should be carried forward with reasonable dispatch, and be completed on or before Jan. 1, 1904. By the terms of the contract it was subject to the approval of the Quartermaster-General of the Army. It was not, however, approved by that officer until April 28, 1903, twenty-two days after the date upon which the contractor should have begun work. Work was not completed until Aug. 31, 1904.

Mr. George A. King of Washington, D. C., arguing the case for the contractor, quoted from Hudson on Building Contracts, 3rd edition, Vol. I (pp. 524, 525), laying down the rule as follows: "Liquidated damages stipulated for at a rate for each day or week of delay in completing the works, must begin to run from some definite date. It follows, therefore, that if there is no date in the contract, or if the date in the contract has for some reason ceased to be the proper date for the completion of the works, there is no date from which liquidated damages can run, and, therefore, all right to recover liquidated damages has gone."

In connection with this principle, he laid stress upon a prior decision of the Supreme Court holding that where a contract is in terms subject to the approval of a designated officer, it does not go into force until that officer has given his approval. Upon this point the court decided the case in favor of the contractor, holding that the failure of the Quartermaster-General to approve the contract until 22 days had elapsed from the time at which, by its terms, the contractor should have entered upon the prosecution of the work, was such a prevention of completion in time as to disable the government from imposing any penalty for the overtime.

The case presented a strong illustration of this principle, as the delay in the approval of the contract only amounted to 22 days while the contractor was 243 days behind time in completion. The court adopted fully the ruling of the New York Court of Appeals in a case cited in its opinion in which that court said: "The defendant having contracted to do this work within a specified time, was bound to have his servants and employees on hand ready to perform within that time. He had the right to assume that the plaintiffs would perform on their part, and therefore could properly contract with other parties for the time of himself and employees for any future time not covered by his contract with the plaintiffs. They could not prevent his performance by delays on their part for even a greater period than that specified in the contract in which he was to perform, and then require him to proceed immediately, for this would require him to do the work at another time than that named in the contract, and when he might be under obligations to other parties."

Judge Atkinson, delivering the opinion of the Court of Claims, thus applied this rule: "It is well settled that where one of the parties to a contract demands strict performance as to time by the other party, he must comply with all of the conditions requisite to enable the other party to perform his part, and a failure on the part of the one demanding performance to do all the preliminary work required by him to enable the other party to complete the work within the time limit, operates as a waiver of the time provision in the contract. It appears that the plaintiff completed the construction of the building in this case within a reasonable time, and that the defendants incurred no expense and suffered no loss in consequence of such delay."

In fairness to the contractor, it should be added that the justice of an extension was fully recognized by the Quartermaster-General of the Army. That office remitted the time penalties on the ground that the contractor had proceeded with all due diligence, and that the failure to complete was owing to circumstances beyond his control. The decision of the court was, however, based upon the proposition of law that the contractor was disabled by the delay of the government from commencing his work on time, and therefore was not chargeable with the stipulated penalty, no matter how great was the delay in completion provided only he proceeded with diligence and completed within a reasonable time.

All this shows the importance of those who let contracts for the performance of construction work allowing sufficient leeway for beginning work after the contract has been reduced to its final form. They should also decide, before making the contract, definitely upon the character of the work to be done so that alterations shall be made only in immaterial details not affecting the time of performance. Otherwise, by substantially delaying the contractor in the performance of his part of the obligation, the owner disables himself from inflicting the liquidated damages provided by the contract.

Double-Tracking the entire Trans-Siberian Railway is proposed in a bill before the Russian Douma, $5,500,000 having already been appropriated for double-tracking 400 miles of line in the Ural Mountains.

A Working Method for Masonry Arch Design.

By William T. Lyle, Assistant Professor of Municipal Engineering, Lafayette College.

A large number of theories have been proposed for the masonry arch, involving various assumptions as to the mechanical nature of the arch ring and the application of the loads. The two principal difficulties which have been encountered are, first, to determine the pressure on the extrados in amount and direction, and, second, to determine the true location of the line of pressure in the arch ring. If earth backfilling is used, horizontal pressures will be developed which are not only a function of the kind of backfilling used, but which may change from day to day in the same structure, on account of changes in the character of the backfilling. Freezing and thawing and variations in the amount of moisture contained account for the changes in the amounts of these horizontal earth pressures.

The following method is not advanced as a new theory, but is believed to be a concise and practical statement of the problem. It does not apply to reinforced concrete arches, which must be treated in accordance with the principles of the elastic theory.

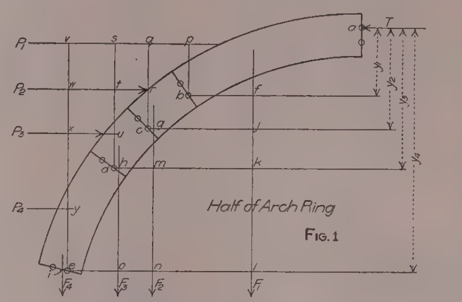


Fig. 1

Mom. around $b = T_1 \times y_1 = F_1 \times bf + P_1 \times bp = A$

" " $c = T_2 \times y_2 = F_1 \times cj + F_2 \times cg + P_1 \times cq + P_2 \times cr = B$

" " $d = T_3 \times y_3 = F_1 \times dk + F_2 \times dm + F_3 \times dh + P_1 \times ds + P_2 \times dt + P_3 \times du = C$

" " $e = T_4 \times y_4 = F_1 \times el + F_2 \times en + F_3 \times eo - F_4 \times ei + P_1 \times ev + P_2 \times ew + P_3 \times ex + P_4 \times ey = D$

Thrust due to moment around $b = A \div y_1 = T_1$

" " " " " $c = B \div y_2 = T_2$

" " " " " $d = C \div y_3 = T_3$ Maximum

" " " " " $e = D \div y_4 = T_4$

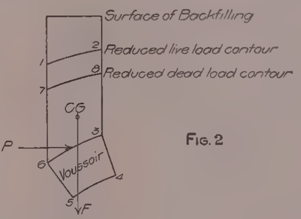


Fig. 2

The design of a masonry arch in accordance with this method is a tentative process. Having decided upon the rise and span, a thickness of arch ring is chosen in the light of experience. Tables containing the dimensions of a large number of actual structures, such as is found in Baker's "Masonry," pages 502 and 503, may prove of considerable assistance.

The arch should be drawn upon a large scale and tested graphically, in accordance with the principles established in the following discussion. Should the arch ring prove to be too thick or thin, a new thickness must be assumed and the process repeated.

The three ways in which arches fail are:

1. By overturning: A, Live load over the full span; B, Live load over part of the span.
2. By sliding.
3. By crushing.

Part A applies to arches of symmetrical curvature whose springing lines may or may not be at the same elevation. Part B is entirely general. If there is a deep cushion of earth over the crown and the arch is of symmetrical curvature, in some cases solution B may be omitted.

The loads are of two classes: First, the weight of the arch ring and backfilling or spandrel arches, and, second, the live load, which is one or more locomotives in the case of a railroad bridge, and which may be a road-roller, one or more electric cars or a human load in the case of a highway bridge.

If the bridge is for a railroad the engine load must be reduced to an equivalent uniform load. The weight per foot will then be divided by the length of a tie, and if earth backfilling is used this intensity of pressure will be still further reduced on the extrados because the pressure is transmitted through the backfilling along diverging lines. If the span is longer than the wheel base of one locomotive and tender, the live load will consist of several locomotives coupled together. If the bridge is for a two-track or a four-track road the weight of each line of locomotives is assumed to rest on a portion of the arch comprised between two vertical planes parallel to the track at a distance apart equal to one-half of the width of soffit in the first case and one-quarter of the width of soffit in the second case, providing that in both cases the clearance between the tracks and the parapets is the customary minimum. Thus, the width of section supporting the load on one track is about 13 ft. 6 in. If the road is single track the load is supported by the whole arch, providing that the clearance on both sides of the track to the parapet is a minimum.

The horizontal intensity of the earth pressure is taken as one-third of the vertical, which, in accordance with Rankine's theory, is the minimum when the angle of repose is 30 deg.

1. *Overturning. A, Live Load over the Full Span.*—Inasmuch as the load is symmetrical, the crown thrust is horizontal. The crown thrust which will be used is the smallest that will insure stability. It will, therefore, act through the upper limit of the middle third of the crown joint, that is, through *a*, Fig. 1, and it will be just large enough to prevent rupture at the critical joint *c*, which is usually about 45 to 50 deg. from the crown.

To ascertain how large must be this minimum thrust: Several joints (either actual or assumed) in the vicinity of the joint of rupture will be selected, in order to determine this joint and to find the corresponding crown thrust. In each joint a moment center will be used, which is one-third of the distance from the intrados to the extrados. By writing an equation of moments in each case, as shown in the figure, the corresponding crown thrust can be determined. Obviously in each case the particular line of pressure passes through the moment center that determined it. There will be a moment center that will give a greater crown thrust than any other. This crown thrust is the one to be used, because if a lesser thrust were used the resulting line of pressure would fall below the lower limit of the middle third of the arch ring. This moment center is in the critical joint, the joint of rupture. Although the corresponding crown thrust is a *maximum* for the reason just given, it is also a *minimum*, because its point of application is at the upper limit of the middle third of the crown joint; therefore, its lever arm is greater than would be the case if the crown thrust were applied lower.

The line of pressure may now be obtained by combining the maximum thrust at *a*, Fig. 1, with the various vertical forces and conjugate pressures belonging to the voussoirs, or arbitrary sections, in case the arch is built of brick, between the crown joint and the joint on which the line of pressure is being located.

Fig. 2 shows a voussoir, with the backfilling above it. By cutting a figure from cardboard, like 1, 2, 3, 4, 5, 6, its center of gravity can be determined by balancing in two directions on a knife edge. Similarly for Part B the center of gravity of 3, 4, 5, 6, 7, 8 can be obtained. The weight of 1, 2, 3, 4, 5, 6 can be computed and its lever arm measured on the drawing. The force P is the horizontal earth pressure on surface 3, 6, determined as previously explained.

B, Live Load over Part of the Span.—If the earth filling is shallow it will be necessary to find a line of pressure for a load over part of the span. This is especially important in the case of railway bridges. The live load is extended over either one-half or two-thirds of the span.

If an equilibrium polygon can be passed through any three points, so as to lie entirely within the middle third of the arch ring, the arch is stable. The loads to be taken are of the same character as before.

Method B is of a general character and can be applied to non-symmetrical arches where the live load extends over the full span or part of the span.

2. *Sliding.*—If the arch is stable as regards overturning, the frictional resistance against the tendency of one section to slide on another, due to the obliquity of the line of pressure, must also be investigated. Sliding will occur when the tangent of the angle between the line of pressure and the normal to a joint is greater than the coefficient of friction. This angle should not be greater than 15 deg.

3. *Crushing.*—Now, by knowing the amount and point of application of the pressure on each joint, the maximum intensity of the compression on that joint can be found, which must not be greater than the allowable working stress. A good value is one-quarter of the nominal crushing strength, as determined by tests. This crushing strength is less than is actually the case in massive masonry. Therefore, the factor of safety is actually greater than four. In the past, arches have been extravagantly designed with regard to crushing.

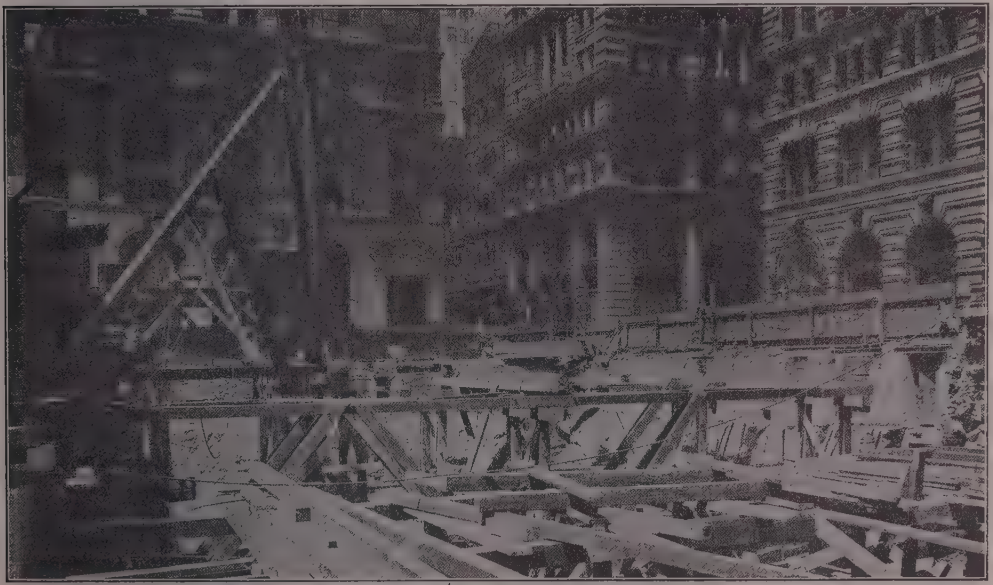
It is well to remember in designing arches that great attention should be paid to the matter of waterproofing. Many arches are improperly designed in this respect.

Surprise Tests on the Union and Southern Pacific lines during the month of March show an efficiency of 98.8 per cent. for the enginemen. The total number of tests made was 1,258. Eighteen kinds of regular signals were employed besides some "specials," including torpedoes, fusees, stop flags, reversed lights, extinguished lights, semaphore arms at danger, and lantern and hand signals. Of the small number of violations, none was of a kind that might have caused a serious accident. Recently the roads have equipped a training-school car fitted with signaling apparatus for the instruction of the employees.

Deep Underpinning for a Brick Factory Building.

Adjacent to the Union National Bank Building, Pittsburg, is a four-story brick structure about 30 ft. front that has been used for a stamp works and contains various kinds of machinery for cutting and punching metal. The original footings of the side walls were about 30 in. wide and were seated about 10 ft. below street level on clay soil underlaid by sand and gravel down to the surface of the rock at a depth of about 85 ft. The Union National Bank Building is a 20-story steel cage structure with its column foundations carried down close together to satisfactory gravel 50 ft. below the curb and the general excavation about 35 ft. deep down to ground water level in fine sand.

It was necessary to remove the wall of the factory building and replace it by a new wall built into the steel framework of the bank building and extended down to its cellar floor. In order to accomplish this without disturbing business operations in the factory building, it was necessary to provide temporary supports for the whole of the latter excepting the opposite party wall, and to safeguard it from danger of settlement or undermining while the new work was being executed. As the excavations alongside were deep and the soil was treacherous, the problem was a difficult one and the simplicity, economy and safety of the methods successfully employed are illustrated by the following description:



Trussed Braces for the Sheeting in Underpinning a Brick Factory Building.

The ends of the floor beams in the different stories of the old building, which were originally supported by the brick party wall, were first temporarily supported on wooden beams placed close to the party wall and carried by vertical shores with horizontal sills and caps in each story and having the sills under the first floor carried by needle beams.

After the floors were thus secured the old party wall was removed and the vertical shores were covered with a sheeting of floor boards and building paper making a temporary enclosure to protect the tenants of the building during reconstruction.

The needle beams passed through both side walls of the building and projected about 10 ft. beyond the face of the party wall, where they were supported on vertical columns about 80 ft. long carried down to the rock before the excavation for the deep cellar was commenced. The opposite ends of the needle beams might have been supported on the other side wall but that its footing was so close to the edge of the deep excavation that there was considered to be some danger of it being undermined, so that it was thought to be more likely that the wall would need support than that it would have ability to give support for added load. Solid foundations were therefore carried down just inside of this wall to the depth of the new cellar excavation and from them the needle beams were supported about 5 ft. from their ends, leaving cantilever extremities carrying the old side wall.

The needle beam foundations inside the factory building were constructed in vertical pits about 4 ft. square excavated by hand under the cellar floor to ground water level and sheeted with horizontal courses of 2-in. planks. This sheeting was placed and braced from the top downward as the excavation progressed, being held securely in position by the external earth pressure while the succeeding courses were added at the bottom of the pit as the lining already in position was undermined. When the pits were completed they were filled solid with second-hand brick laid edgeways and grouted in crossed courses. Short timber cribs were built on the tops of the piers and on them were seated jackscrews bearing two lines of continuous 12 x 12-in. horizontal timbers parallel to the side wall on which the needle beams were seated.

Two well-drilling machines were installed on the site of the bank building and with them a single row of 8-in. holes was driven to a depth of about 18 in. below the surface of the rock. The center line of the row was about 10 ft. beyond the face of the wall. The holes were drilled in sets of two or three about 3 ft. apart on centers. In each hole there was driven a heavy 6-in. gas pipe casing made up of 20-ft. sections coupled with outside screwed sleeves and filled with concrete thoroughly compacted by a heavy rammer operated by a hand line.

The tops of the columns thus formed were cut off in the same horizontal plane by a hand cutting machine and on them was seated a 10-in. I-beam with horizontal web. Holes were punched through the I-beam web to receive the nuts of jackscrews, some of which projected through into the supporting columns, and a continuous 12 x 12-in. timber was seated on the jackscrews to receive the outer ends of the needle beams. All of the jackscrews were set up uniformly and lifted both ends of the needle beams, thus supporting both walls of the old building.

The gas pipe columns were braced longitudinally by three horizontal double lines of 6 x 8-in. struts clamped across both sides and were first braced transversely by diagonal struts from the middle row of longitudinal struts to the needle beams inside of the party wall.

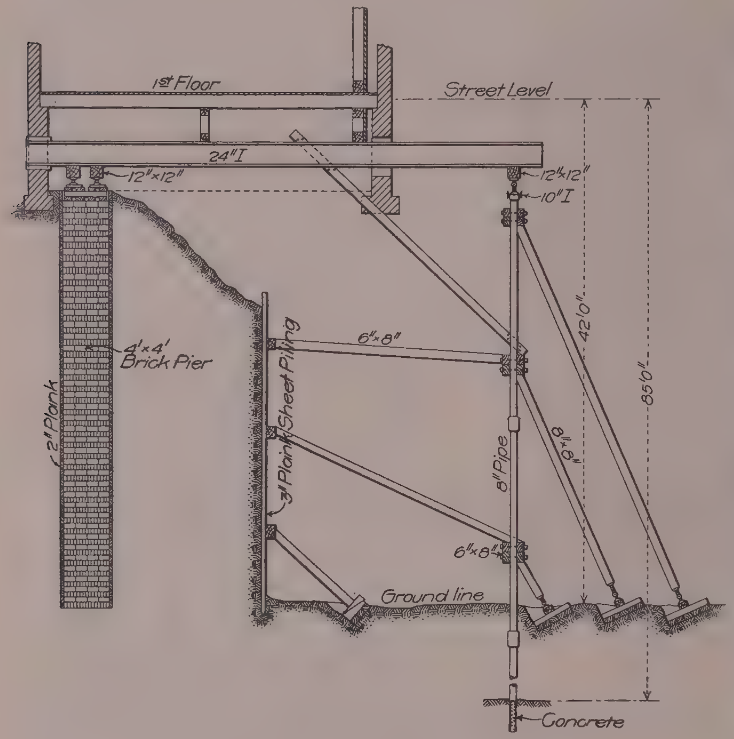
As the excavation progressed the earth under the factory building was removed to a natural slope of about 45 deg. from the top of the underpinning piers to a level about 21 ft. below the street, below which it was retained by a line of 3-in. sheet piling about 10 ft. from the center of the party wall, which was driven to a short distance below the ground water line and the bottom of the new cellar excavation. This sheeting sustained a heavy pressure and surcharge and was braced as shown in the diagram by inclined struts, two rows of which engaged the lower longitudinal struts connecting the gas pipe columns. The latter were held firmly in position by their heavy loads and the horizontal thrust transmitted to it was resisted by 8 x 8-in. inclined shores engaging the intersections of the columns and longitudinal struts at their upper ends and seated at their lower ends on jackscrews with inclined grillage footings embedded at right angles to them in the bottom of the excavation. A third set of similar inclined shores braced the upper ends of the columns and effectually resisted any possible tendency of the needle beams to move longitudinally. This arrangement provided for the support and bracing of the old building and of the soft earth and caused a minimum obstruction in the deep excavation, allowing the new structure to be built there without difficulty. This method of underpinning has proved efficient and satisfactory and has been used by the same contractors for various other jobs.

The well drilling machines were operated simultaneously with the general excavation and the spoil from the latter was removed in wagons drawn by teams up an inclined wooden runway to street level. A berm about 3 ft. wide was left adjacent to the old vault walls on the street sides of the lot and the sides of the pit were sloped down steeply from it to a depth of about 20 ft., and stood for some time without retaining. As the excavation was carried down around the 6-in. pipes the latter were secured by the inclined braces, already mentioned, which were successively replaced by longer and longer pieces as the excavation progressed.

Work was commenced about the 1st of April, 1907, and by the end of the month the excavation was so deep that the soil could no longer be advantageously removed over the incline runway, and a derrick, afterwards used for handling the steel work, was installed near the factory building about the middle of the long side of the lot, being located to command nearly all portions of its area. The derrick mast was supported on a four-post wooden tower carried down about 50 ft. below curb in a sheeted pit. The outer ends of the derrick sills were carried on the longitudinal timbers supporting the needle beams under the factory wall and a platform on them carried the hoisting engine which was set on springs to prevent the transmission of vibrations to the building.

The spoil from the remainder of the excavation was shoveled into steel buckets and delivered by the derrick to wagons in the street. When the excavation reached the foot of the derrick tower the latter was supported on four transverse 12-in. I-beams about 20 ft. long, borrowed from the building, which served as needles. The ends of the beams were carried on cribbing piers between which the excavation was carried down several ft. farther under the tower to provide for a pier foundation at this point. The pits for the other foundation piers were sunk below the general excavation with wooden sheeting and finally the three sides of the excavation were retained by 2-in. wooden sheeting with horizontal lines of waling pieces about 8 ft. apart vertically. The waling pieces were braced across the full width of the lot with 12 x 16-in. horizontal timbers 22 ft. apart, supported by vertical pieces at one or two intermediate points. Each strut was made in two pieces, butt-jointed and spliced with short cover planks bolted on all four sides. A short drum was spliced to each end of each strut and the jackscrew it contained was set up hard against the waling piece.

The Commonwealth Trust Building, adjacent to the bank building, has the same width and the excavation for it was made simultaneous with that for the bank building and was executed in essentially the same manner. It was, however, carried to a greater depth and the sides of the pit were retained by wooden sheet piles driven by a steam hammer. The hammer was operated from a tower about 30 ft. high with its sills skidded across the tops of the horizontal struts in the planes of the waling pieces. These struts were much lighter and closer together than those used for the National Bank Building and were made in three pieces each. The upper and lower struts in the same vertical planes were braced together with pairs of vertical and diagonal planks bolted on both sides, forming trusses which increased the strength of the compression members and diminished their deflection.



Underpinning of Column and Pier.

Derrick Tower and Underpinning Pipes.

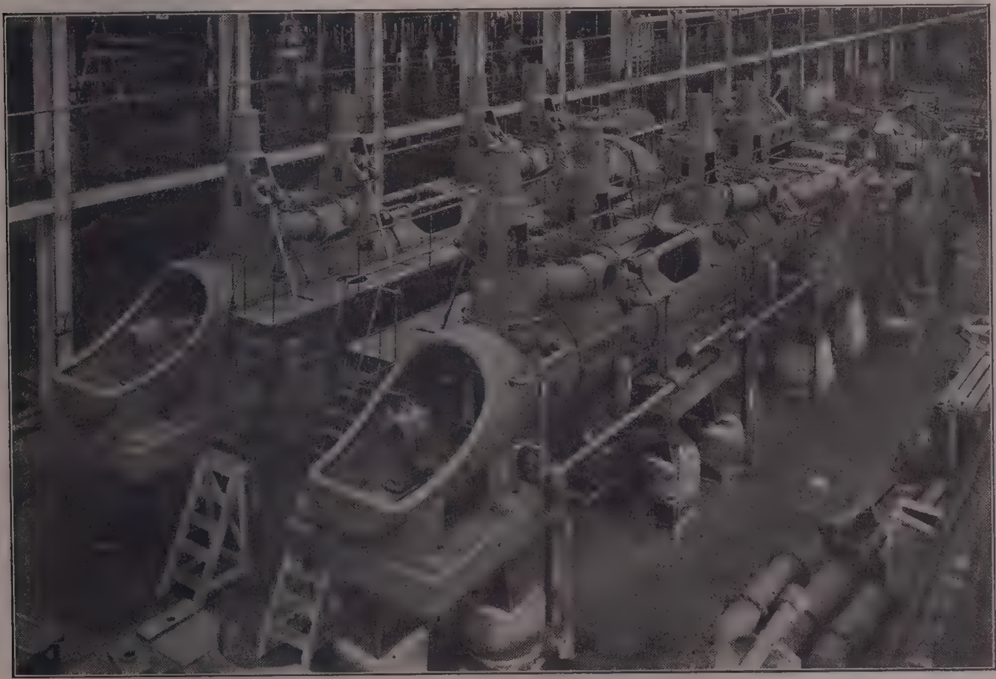
A Reinforced Concrete Trestle has recently been constructed by the Chicago, Burlington & Quincy Railway to replace the single-track timber-trestle approach to a truss bridge over Salt River, about 100 miles north of St. Louis. The length is 477 ft. 6 in. The bents, which are composed of six piles each, are spaced on 14-ft. centers. The piles are 22 ft. long, 16 in. square at the top, taper 8 in. in 30 ft., and are chamfered 3 in. on the corners. They were driven with a 3,000-lb. hammer into gravelly sand, the penetration being 14 to 16 ft. The tops were capped with a reinforced concrete beam which carries the 19-in. trough-shaped floor slab, 14 ft. wide over all. A pier resting on wooden piling at every fifth span takes the longitudinal thrust. The trestle was designed by Mr. C. H. Cartlidge, bridge engineer of the Burlington.

Large Gas Engines for the Steel Works at Gary.

In view of the successful results that have been obtained from a number of large gas engines at its Pittsburg furnaces, the United States Steel Corporation adopted engines of this type to operate on the gas from its blast furnaces to be built at the great steel works at Gary, Ind. Sixteen blast furnaces are being erected for the operation of which five large gas-blowing engines of the horizontal type are being built by the Westinghouse Machine Co., East Pittsburg, Pa., which are designed for ratings of approximately 3,000 h.-p. Several of these units have recently been completed at the works of the builders, and from it the following interesting constructional details are to be noted, these units being of the largest capacity that have been constructed by this company.

The Gary engines are of the horizontal twin tandem construction, having four double-acting cylinders which are operated on the four-stroke cycle, with cranks set 90 deg. apart, giving thus four impulses per revolution of the crank-shaft. They have cylinders 42 in. in diameter by 54 in. stroke, and operate at a speed of from 60 to 75 r.m.p., at which speed they have a rating from 2,900 to 3,000 b.h.p., according to the richness of the gas from the furnaces. The blowing cylinders are of the Slick type, the invention of Mr. Edward Slick, of the United States Steel Corporation. There are two air cylinders to each engine, one connected in front of either set of tandem cylinders by extension rods from the main cross-heads. The tubs are designed for the delivery of air at a normal pressure of 15 lb. per square inch, with capacity for a maximum of 25 lb. for short intervals if necessary.

The engine embodies a number of interesting features in design and construction which combine to simplify operation and maintenance. What are, perhaps, the most striking features of the new Westinghouse design, are in the inlet valve construction, a combination of the functions of inlet, mixing and governor valves in a single mechanism, one eccentric operating both inlet and exhaust valves, electro-magnetic igniters, relay governing and automatic starting. The arrangement of inlet valves is also such that the compression clearance in any cylinder can be changed to suit various gases without altering the cylinder piston or valves, and the pistons are "floated" on the rods, their weight being carried on the cross-heads. All parts of the engine exposed to the heat of combustion are water cooled with the exception of the inlet valve, and a split jacket band, easily removable, permits of ready access to the water jacket space for cleaning out. The side crank construction of the twin tandem arrangement permits of support of the shaft with but two points for alignment, and the main bearings are so constructed that shells may be removed without disturbing the crank shaft. All cylinders have at least two separate igniter plugs, each with both sides of the circuit carefully insulated from the frame and means whereby the exhaust valves may be held open, permitting the plugs to be removed while the engine is in operation. Starting is accomplished by an automatic compressed air starting system, controlled by a single valve, which continues in operation until all igniters are working properly, and automatic safety stops are provided which operate in case of overspeeding or loss of water in the cooling system.



The Large Blast Furnace Gas Engines for the Steel Works at Gary.

The general appearance of one of these engines is shown by the accompanying illustration of one of the Gary engines, as erected in the shops of the Westinghouse Machine Co., without crank shaft, before shipment. A noticeable feature of the general design is the accessibility to all parts on both upper and lower levels, platforms between the pairs of cylinders allowing access to the upper valve gear while below, free space is left between the pedestals supporting the cylinder ends, which permits of access to the exhaust valves from platforms in the basement underneath the cylinders. The main frame of the engine consists of a front housing which supports the main bearings and cylinder and air tub connections, and a cylindrical housing between the cylinders. The center and rear housings are of approximately similar construction, with the tops cut away to permit access to the cylinder heads, the openings thus made in the tops of the housings being reinforced by removable steel struts. The cylinders are all anchored to the foundation at the main housing only, and are arranged to slide in machined ways at the center and rear housings, so as to permit of free expansion and contraction longitudinally with temperature changes. The front housing or main frame is a one-piece casting of box-girder type heavily ribbed to withstand the transverse stresses that result from the side crank design. The box frame completely surrounds the crank pit, forming a rectangular bed, which is anchored at the four corners. Access to the cross-head is obtained through open windows in the housing, while the depression formed by the crank pit serves as an oil well, from which excess oil is drawn off and filtered for return to the oiling system. The main bearings are made in four parts, two of which are adjustable by wedges. The principal features of the design of these bearings are that they are self-centering, their brasses removable without disturbing the shaft, and heavy tie rods through the uprights above the shaft in place of the usual lips cast on the edges of the bearing caps for the purpose of tying the housings together.

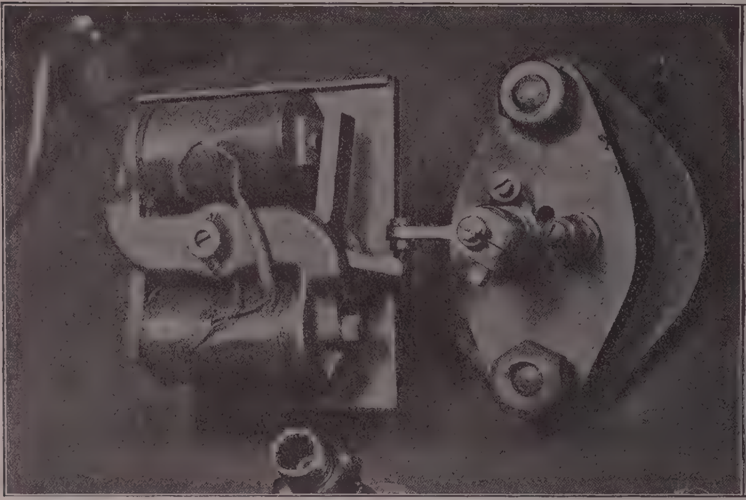
The cylinders are of special design, cast in halves, each containing an inlet and an exhaust valve opening, and a part of the water jacket. The two halves of the cylinder are fitted together with a ground joint at the center, and are held securely together by arrow-heads shrunk in rims projecting from the end of either half into the water jacket space. The jacket walls are purposely left open at the center in order to facilitate making the central joint, and give access to the jacket space, and the opening is closed by a split jacket band, which is fitted in with a water-tight joint, permitting free expansion and contraction of the cylinders. An advantage of this construction is that the removal of this jacket band gives ample access to all of the water spaces for cleaning. Similarly the jackets around the exhaust valves are accessible by removing a retaining ring at the bottom without disturbing the valve bonnets. Access to the interior of the cylinders is similarly facilitated through the valve openings.

The features of the piston construction are the perfectly symmetrical design with absence of internal webs and sharp corners to cause premature ignition, and the permanent mounting on the piston rod, being forced on by a pressed fit and secured by retaining nut, which was turned off flush with the piston. Each piston is fitted with four packing rings of the sectional type, the sections being held out by flat steel springs and joined by brass keepers, and by the use of tail-rod crossheads, the piston is floated concentric with the cylinder bore, which leaves several annular spaces between the rings into which the oil is injected and distributed. The piston rods are of steel, 12 in. in diameter outside, bored from either end to the piston for water cooling, and are made in two parts, joined at the center cross-head by a split threaded coupling, thus minimizing the building clearance necessary for removing pistons. The rod is supported by three cross-heads, one the connecting-rod cross-head, and the others, guides at the center and rear ends, and in these cross heads are made the provisions for centering the rod, consisting of a wedge slipper in the main cross-head and shims in the center and rear cross heads. The rods are all packed by sectional metallic packing, floating on the rods and supported by springs to take the weight off the rods. They are lubricated from the positive feed cylinder oil pumps, the oil being injected at about the middle of the sections and working both ways.

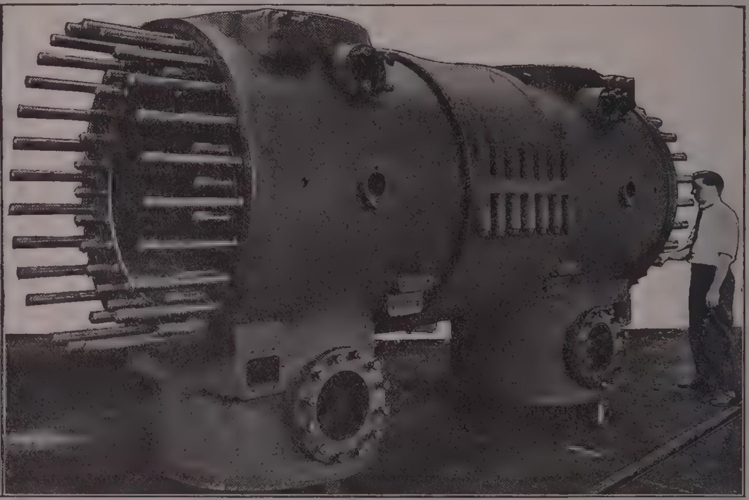
The crank shafts of the engines are solid forged steel 30 in. in diameter, carrying a 24-ft. flywheel at the middle, and on either end of which are pressed solid cast-steel crank discs. A feature of the crank construction is that the pins are cast integral with them, which construction eliminates the possibility of the metal between the crank pin and the crank shaft bore being strained in making a press fit. A further precaution was taken in casting the cranks with the crank pin ends at the bottom of the mold in order to insure solid metal in that part. The connecting rods are steel forgings of the solid-end type, and are designed for a crank ratio of 5.5 to 1. They have the usual wedge and bolt adjustments with babbitted boxes at both ends.

A detail of the engine that is considered of considerable importance is the valve arrangement involving diametrically opposite locations for the inlet and exhaust valves at the ends of the cylinders, which results in a symmetrical cylinder structure, the provision of the maximum distance between inlet and exhaust openings for minimum dilution of the incoming mixture with the spent gases, and also provides two large openings in the cylinder structure through which inspection of the interior is facilitated without removing the cylinder heads. An advantage of this design is that the cylinder clearance may be readily altered for adjusting the compression to suit gases of various qualities, which is accomplished by varying the bulk of the protruding cylinder head or packing cage, which thus involves no changes in the cylinder or piston construction. The valves used are of the poppet pattern, of solid forged steel for the inlets, and hollow cast-iron for the exhaust, the valve springs being located on the extended valve stems, so as to be well removed from the heat of the cylinder. The exhaust valves are hollow, and have a special arrangement for water-cooling, the water entering through the annular space between an internal tube and the outside of the valve stem so that the coolest water is always in contact with the stem; the discharge is through the tube, which is extended within to the top of the valve, so that air pockets are avoided and the valves kept full of water. The stems of both valves are lubricated at the mid-point of the stem bushings.

The inlet valves are of a novel design, which combine the functions of an inlet, mixing and governor valve in a single mechanism, by means of which a number of advantages are obtained. The mechanism consists of the spring operated poppet valve, a stationary cage and bonnet in which it is housed, and a mixing or regulating valve sleeve that reciprocates within the cage and rotates on the inlet valve stem. The mechanism has, in fact, three distinct movements: First, the vertical movement of the valve transmitted from the eccentric; second, the vertical movement of the regulating sleeve, which is carried with the valve stem, and third, the rotation of this sleeve on the valve stem, as actuated by the governor mechanism. The regulating sleeve is a cylinder which has two sets of ports, one for gas and the other for air, which register with corresponding openings within the valve cage that connect with gas and air supplies; the action of the mechanism is such that, when the valve is closed, this sleeve is raised and closes both ports, but as the valve opens, it drops and uncovers the ports, the amount of the opening in either set of ports depending upon the angular position of the sleeve in its rotation about the valve stem as controlled by the governor. The result of this arrangement is that the gas and air are mixed directly at the point of entrance to the cylinder, and only as needed by the engine, which avoids large quantities of idle mixed gases in intake connections, and results in giving the governor absolute control over the engine. Incidentally a very small amount of mixed gas is involved in case of a back fire. An additional advantage is to be noted in that the constant movement of the valve mechanism, which results in this design, prevents any possibility of the governor valve sticking when the engine is run on constant loads for long periods. Furthermore, as the mixture at each end of each cylinder is independently controlled by the governor, a closer speed regulation has been found possible, the angular variation of the flywheel velocity having been found such with this type of engine and governor construction that no difficulty is experienced in the operation of alternating current generators of standard frequencies, in parallel. The standard flywheels furnished on these engines are of such proportions that with one cylinder out of commission, the angular variation will be within the limits prescribed for steam practice. Thus, with all four cylinders in operation, the angular variation is less than in standard steam engine practice.



New Magnetic Igniter Mechanism.



One of the Complete Cylinder Units.

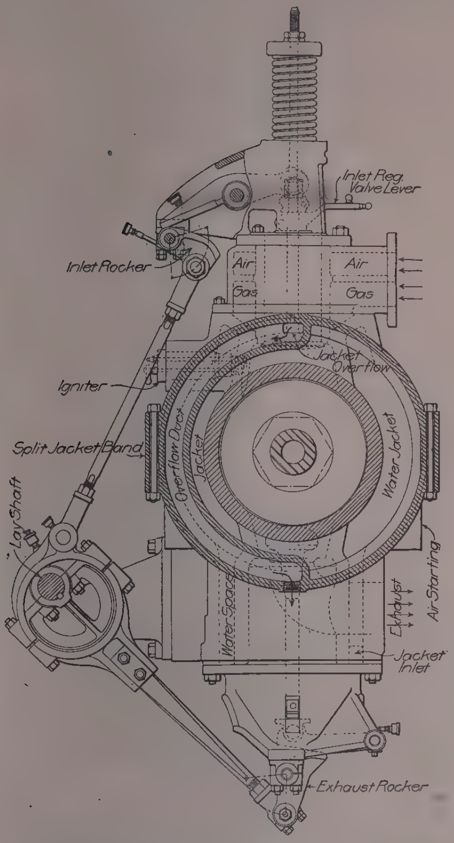
The valve gear is operated from the usual lay shaft arranged horizontally at the side of the cylinders, but a novelty has been introduced in that both inlet and exhaust valves are operated from a single eccentric at each end of each cylinder, and the use of rolling cams, by means of which large initial power is applied to the valve rockers in opening the valves, and a very rapid opening and closing is obtained. The valve cams are, as shown in the accompanying drawing of the valve mechanism, similar in form to the well-known rolling cam gear of river-boat engine construction, and act with variable leverages, the greatest occurring at the initial openings of the valves. This is a particular advantage for the exhaust valve, which must be opened against the pressure, but is similarly of advantage to both inlet and exhaust valves in that the closure, while very rapid, is rendered easy with the entire elimination of hammering on seats. A precaution is taken to prevent interference with the timing of this engine by dowelling the eccentric push rods in place, the slight adjustment necessary to secure easy seating of the valves being provided for by shims in the rocker arm bearings by which also the slight wear on the cam faces is compensated for. The lay shafts are driven from the main crank shaft by a combination of spur and bevel gearing, each with a "hunting" tooth, the use of spiral gearing for this purpose having been abandoned in order to obviate the back lash which is unavoidable when the spiral gearing wears, and also to obviate the necessity of thrust bearings.

The governing system used employs a centrifugal type of governor, with rectilinear motion of weights, which operates the regulating sleeves of the valve mechanisms through an oil cylinder with relay control. The governor merely operates a small pilot valve which admits oil under pressure to either end of the operating cylinder that actuates the mixing valves of the main cylinders through long reach rods. The reach rod on either side is connected with ball and socket joints serially to the regulating sleeves of each of the valves of the two cylinders, and is thus in four sections, which are subject to a certain amount of lateral motion as the valves and sleeves are depressed in opening, but the lateral motion is so slight as compared with that necessary to materially change the adjustment of the regulating sleeves, that no effect upon the governing is traceable to this form of reach-rod connection. The governor used for operating the pilot is of American construction, the Jahns, and is connected to the pilot valve with a bell crank and link connection, with the dash pot to prevent hunting on fluctuating loads. The pilot valve is interlinked with the oil cylinder pistons, and is designed for position control of the piston upon the principle of the pilot control steam steering gear used on shipboard, or similarly controlled elevator operating valves, as used in hydraulic elevator service. The governor is driven from the main crank shaft rather than the lay shaft, so as to be unaffected by any slight torsion to which the latter may be subjected.

The automatic safety stops are made independent of the governor, that operating from overspeed consisting of a centrifugal attachment in the rim of the flywheel, which operates under excessive speed to open a switch in the igniter circuit of the engine, while the other is for failure of the jacket water supply, and operates through a diaphragm mechanism. The former is of a very simple construction, consisting of a spring balanced pin, supported in the rim of the flywheel, which, in case the speed exceeds a predetermined limit, is forced out by centrifugal force and strikes a stationary pawl mounted outside of the rim that is utilized for kicking open a knife switch in the igniter circuit. The jacket water stop consists of a water pressure diaphragm that is arranged to similarly open a knife switch in the igniter circuit if the pressure of the cooling water supply gives out, as in cases of stoppage of flow.

For the ignition, the make and break system has been adopted, the jump spark system of ignition having been found impracticable, except for small engines or those operating on low composition and rich gas. For a maximum of reliability, two sets of igniters are provided in duplicate for each end of each cylinder, and a simple design of igniter plug is used with igniter contacts of cast-iron, which have been found to have remarkable wearing qualities with the low current values required for ignition. The igniters are one-piece plugs inserted into openings into the compression spaces of the cylinders with one ground joint, which carries the fixed and moving parts. The former is protected by an insulated sleeve which passes through the hollow space of the igniter plug with heavy mica washer insulation at either end. As both sides of each igniter circuit is therefore thoroughly insulated, troubles from grounds are minimized, it being, in fact, necessary for both sides of the circuit to be grounded before the igniter becomes inoperative. A feature of the mechanically driven igniter mechanism is the use of a magnetic indicator to show at all times the conditions of the various igniter circuits, which consist of small sounders attached to the inductance coil of each of the igniter circuits, so that if any igniter should fail, it is visibly indicated at once to the attendants by the failure of the sounder of its inductance coil to operate regularly. An important feature of this new horizontal engine design is the provision that is made for removing the igniters while the engine is in operation, this being accomplished by shutting off the gas supply to the cylinder from which the igniter is to be removed, and blocking open the exhaust valves by cams provided for this purpose, which permits the igniters to be removed without difficulty.

The two forms of the ignition gear have been employed on the Westinghouse horizontal engine, a mechanical gear and an electrical gear, although in most cases only the electrical gear will be fitted. The mechanical gear, as fitted on the Carnegie engines, consists of a small lay shaft carrying the igniter knock-off cams, having a mechanical device between the igniter lay shaft and the main lay shaft for advancing or retarding the spark to meet the requirements of gases of varying richness. This device for changing the point of ignition, consists of a sleeve having internal spiral grooves engaging pins on the igniter lay shaft. This sleeve is free to revolve with the igniter lay shaft, but can be moved backward and forward by a calibrated hand-wheel, thus changing the relative positions of the main and igniter lay shafts. The igniter lay shaft is driven from the main shaft at a point near the forward part of the engine to avoid advancing or retarding the ignition due to twisting of the main lay shaft.



Details of the Cylinder and Valve Gear.

The electrical ignition gear consists of a timer or contractor for making and breaking the ignition circuits, and in place of the igniter knock-off cams used on the mechanical gear, an electrical knock-off device is employed. This consists of two electro magnets wound in series with an S-shaped armature carrying a hammer which strikes the igniter and trips same when the electro-magnets are energized. The advantages of this system are that the ignition is easily advanced and retarded, the same as a mechanical gear, and that all the igniters at each end of each cylinder operate simultaneously.

The cooling system of these engines has received special attention, a series system having, after much experimentation, been adopted which minimizes the amount of water used. Each cylinder has, with the new arrangement, but two independent water circuits, one through exhaust valves to the cylinder jacket and the other serially through the exhaust valve cages, thence to the two cylinder heads and finally through the piston rod and piston, an arrangement somewhat on the countercurrent principle, in that the coldest water surrounds the hottest rod. The piston connections are of the tube or "trombone" type, arranged on a bracket carried by the center cross head, the tubes reciprocating with the piston rod movement into packed cylinders that have large air chambers to neutralize the effect of the surging of the water.

General lubrication for the engine is supplied by a continuous gravity system, with filters, insuring ample lubrication of all bearings, crank pins, crossheads, etc., while that for the cylinders is supplied by means of a timed forced lubrication system which supplies the oil at four points in the upper quadrant of each cylinder during the suction stroke only, a point of importance, as it gives two working strokes at low temperature during which the cylinder oil is evenly distributed over the entire surface of the cylinder and thus insures perfect lubrication with a minimum supply of oil. The even distribution of oil to the cylinder surfaces is insured by the fact that the pistons do not touch the cylinders at any point, and that the oil is forced in only when the piston is directly under the oil ports so that the recesses between piston rings distribute the oil evenly. The entire lubrication is controlled by one valve without disturbing the individual adjustments of the lubricators, and all important parts are lubricated by sight-feed oilers.

The engines are provided with an automatic air starting system, consisting of an air supply pipe, fitted with an unbalanced poppet valve, which is connected to each end of each cylinder, the poppet valve being located directly under the air knock-off cam mounted on the main lay shaft. To start the engine, it is only necessary to turn on the main air valve which causes the poppet valves to move upwards to their seats. One or more of these poppet valves will be held down and open by the air cam, thus admitting air to one end of the cylinder, causing the engine to turn over. As the air is admitted to the cylinder only during the power stroke, the exhaust valves are opened on the succeeding stroke and permit the escape of the air from the cylinder.

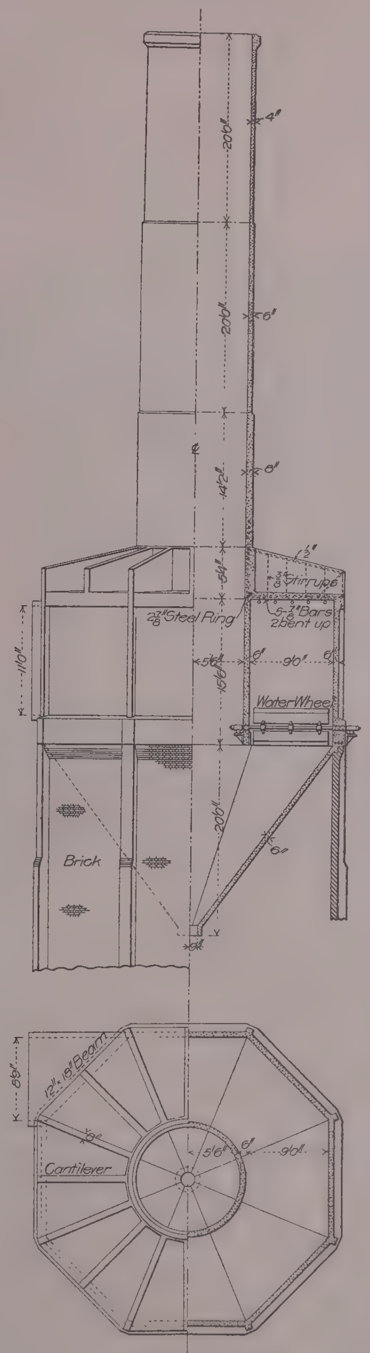
Cumberland Mills Chimney.

EXCAVATING HARDPAN of a heavy gummy character cost about 20 cents per cubic yard on the Grand Canal of the Salt River project of the U. S. Reclamation Service. The work was done in January, when 25,060 cu. yd. were taken out, some time being lost on account of bad weather. Common labor cost $2 per 8-hr. day, drivers $2.25 per day, foremen $4 per day, and horses about 71 cents a day including feed.

An Unusual Concrete Chimney.

An interesting use of reinforced concrete for a peculiar combination of chimney, smoke and spark arrester has been designed and constructed for S. D. Warren & Co., Cumberland Mills, Me., by the Aberthaw Construction Co., of Boston. As shown in the sectional view, the entire chimney is supported upon sixteen cantilevers extending from the chimney to the circumference of the arrester. It was the purpose of this novel arrangement to overcome the annoyance and expense resulting from particles of soot falling upon and being retained by the fine grades of paper manufactured by the owners.

The spark arresting portion of the structure is of octagonal cross section. The products of combustion enter at the periphery of the arrester and under the action of mechanical draft are given a whirling motion. They finally pass down into the inverted conical catch-basin and thence up through the chimney. The problem which confronted the Aberthaw Construction Co. was that of supporting a 60-ft. chimney 11 ft. in



Details of Concrete Chimney.

diameter upon the roof of the octagonal smoke and spark arrester, which measured 32 ft. between paralled faces. Obviously it was not permissible to extend supports across the entire diameter because of the obstruction which they would present to the passage of gases up the chimney. Sixteen reinforced concrete cantilever beams radiating from the chimney to the middle of the sides and corners of the spark arrester were therefore provided as a means of support. These are naturally tied together by the circumferential reinforcement of the chimney and serve to support the roof.

The chimney was built in three vertical sections of 20 ft. each; the thickness of wall varying in each section from 8 in. at the bottom to 4 in. at the top. As the season was somewhat advanced at the time of building and as there was some delay in the arrival of concrete materials, the supporting wall was made of brick. Reinforced concrete was used throughout the balance of the construction.

The chimney and that portion of it extending downward about 15 ft. into the spark arrester was reinforced vertically by ⅜-in. bars of 12 in. center to center and horizontally by ⅜-in. hoops similarly placed. The cantilever reinforcement consists of five ⅞-in. bars at the bottom bent at the chimney wall and extending eight feet up it. At the opposite end two bars are bent up at an angle of 45 deg. Additional reinforcement is furnished by a 2⅞-in. steel ring encircling the ⅞-in. bars at the bend in the chimney wall. Looped around the ⅞-in. bars a ½-in. bar in the top and outer end of each cantilever takes care of any tension which might occur in those portions. Five stirrups spaced 24 in. on centers also encircle the ⅞-in. bars at the bottom.

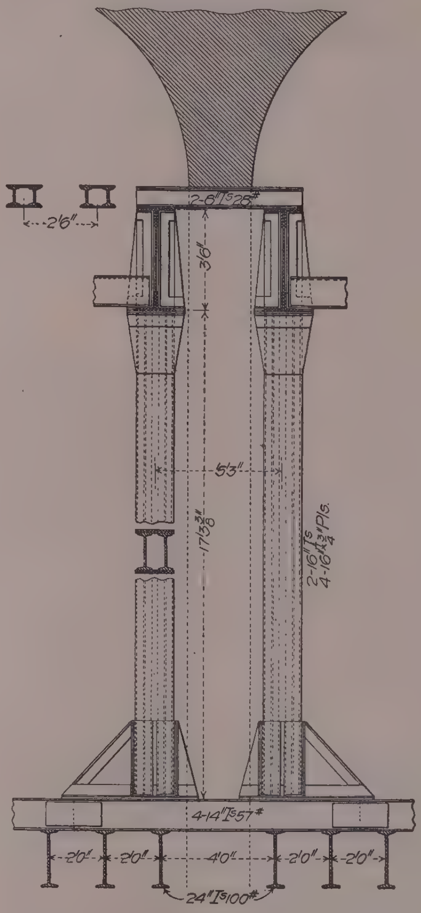
The total height of the chimney is 100 ft., the height to the bottom of the cantilevers being 40 ft.

Cutting a Subway through Masonry Bridge Piers.

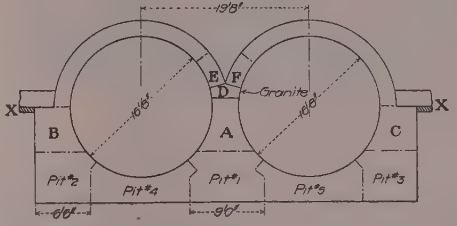
In order to provide a connection between its tramways on the north and south of the River Thames, London, the London County Council some years ago decided to construct a subway starting from the Embankment at the Middlesex abutment of Waterloo Bridge and joining up with the subway which already exists beneath the westward arm of Aldwych. The subaqueous portion of the line was driven by the shield method without encountering any unusual difficulties, but part of the approach to the river section offered a troublesome problem, since the line cuts under the Waterloo Bridge approach, which is carried on arches supported by fifteen brick piers. The methods of cutting through these piers and of building new supports for the arches were described in a late issue of "The Engineer," London, from which these notes are taken.

The brick piers extend sideways across the road and footpaths, are placed at about 18-ft. centers, and with the exception of the two nearest the bridge, which are 3 ft. thick, are all 2 ft. 3 in. Both the bricks and the lime mortar in which they are set are extremely good and hard, and there is practically not a crack to be seen in any of them. There is, however, a very old crack in the end abutment, and to this we shall refer later on. That the piers should show no cracks or sign of settlement is all the more to be wondered at, seeing that they are built directly on the mud, and have no proper foundations at all, saving a wooden grid of 4-in. pitch pine, 4 ft. 6 in. wide, which in most cases was found to be in a wonderfully good state of preservation.

It was necessary, of course, to cut holes out of each of these piers in order to provide passageway for the tram-cars. To have simply cut these holes and not take any further precautions was, of course, out of the question, and the method of taking the weight which has been employed is shown in the engraving. Steel columns have been erected in pairs on each side of each pier. On the tops of the two columns on each side of the piers have been fixed plate girders, these being parallel to each other and to the piers. Holes were then cut through the piers at the level of the tops of the cross girders and needle beams passed through these holes. These needle beams rest on the cross girders, and were not, of course, all put in at once. A commencement was made with that at the center. When this had been got into position and built into the pier with carefully cemented and wedged brickwork, several days were allowed to elapse before the next hole on one side of it was broached, and so on. As more beams were got in, two holes were allowed to be cut at a time, one on either side of the first, but never more than two. The position chosen for these beams was just below a stone course from which the arches spring. The general method is shown in the drawing. The nature of the ground necessitated foundation work of a peculiar character.



Steel Work Supporting Arches.



Sequence of Operations in Cutting through the 5-Foot Wall.

It was originally intended, before the ground was opened up, to erect the columns on the foundations of concrete carried down to the clay. When investigations came to be made, however, it was found that the piers had no foundations at all, and that, moreover, in several instances their bottoms actually came some distance above the level of the bases of the steel columns. This, of course, necessitated the provision of a proper foundation, and after consideration it was determined that the most satisfactory thing to do was to form a raft of reinforced concrete throughout the whole length and breadth of the work. This was made 6 ft. 6 in. deep, and was formed of 6 to 1 Portland cement concrete. The reinforcement consisted of I-beams, 24 in. by 7½ in. by 100 lb. Where the foundations of the piers had been taken down to a sufficient depth this concrete floor was only laid in between the piers, but where this was not so the flooring or raft was taken right underneath the footings of the piers, the latter having, of course, to be underpinned. In some cases the footings of the piers were several feet above the top surface of the raft. On the top of the cross beams longitudinal beams were arranged in sets on both sides, so as to form a solid foundation for the steel columns. The longitudinal beams were 14 in. by 6 in. by 57 lb. They were all of the same type, and were 17 ft. 3⅜ in. high. On their tops and running parallel to the pier walls, were fixed the main girders. This combination made a thoroughly sound and substantial basis on which to carry the needle beams for carrying the weight of the brick arches supporting the roadway.

The needle beams were ordinary I-beams, 8 by 5 in. by 25 lb., arranged in pairs in box form, with a 15 by ¾ in. plate, riveted top and bottom, the interior space of the box being grouted in with 6 to 1 Portland cement concrete. These needle beams were placed at 2 ft. 6 in. centers and were inserted in the manner already described. This method of construction was used until the entrance to the two tunnels was approached, when the tram lines diverged slightly, and it became necessary to have a central pair of columns, as well as the pairs on each side. Girders, were, however, used in the same manner as in the case of the other pairs, but they were rather shorter.

Having got all the columns, cross beams, and needle beams into position, and having allowed a sufficient time to elapse for the brickwork in cement, in which the beams were set, to harden properly, the brickwork of the piers was cut away, and it was found that in every case the underpinning had been successful, and that there was no sign whatever of cracks or settlement. In order to permit of access to the work originally, it was necessary to cut passages in the brickwork of the piers. These were made about 8 ft. square, and in some cases wooden beams were let in at the top as supports. The cutting of these holes in no case caused any cracks to develop. When all the brickwork of the piers had been cut away the exposed surfaces were finished off smooth, and the columns themselves encased in brickwork.

The wall beyond the approach arches remote from the river was approximately 5 ft. thick, and here another interesting problem was encountered. It was necessary to cut two holes 3 ft. apart and 16 ft. 8 in. in diameter in this, in order that the shields for excavating the twin tunnels might be got to work. In this was the only crack which was found in the whole of the old brickwork, and on its account extra precautions were taken. Before operations were commenced pats of cement were placed in various positions along this crack, and when the work was finished these pats were all intact, showing that no settlement whatever had taken place.

The method employed in cutting out the two openings was ingenious. It is illustrated in the drawing. The work was much complicated by the fact that the brickwork of the abutment wall only came down to the level shown by the line X X. The first operation was to excavate pit No. 1, which is 9 ft. across, and fill it with 6 to 1 Portland cement concrete. When this foundation was properly hardened, the ground and brickwork above it was removed and the brickwork shown at A was carefully constructed in blue Staffordshire bricks set in cement. A square hole was then cut right through the abutment, and the granite block D got into position. The space between the blue brick pier thus formed and the side of the excavation was then packed with stock brickwork in weak mortar to serve as a temporary support. On the granite block D were then built the two portions E and F, also in blue bricks in cement, which formed the springings of the two arches, just entering into the solid brickwork above them, being let into holes cut out for the purpose. The depth of the brickwork in both arches was 1 ft. 11½ in.

When all this had had sufficient time to set and harden, the second pit shown at the left-hand side was excavated and filled with concrete, and when this in its turn had hardened, the brickwork B above it was built up and formed a partial support for the brickwork of the abutment. The same process was carried out with pit No. 3 on the right-hand side and with the brickwork. Therefore the brickwork of both arches was gradually got in by first cutting away the wall and then building a little bit on one side and then a little bit on the other, this being done in the case of each arch. When this was completed, and when the brickwork had properly set, the whole of the remaining semicircular internal portion of the abutment wall was removed, the new arches then taking the weight of the brickwork above. It is interesting to note that the centering on which the arches were built consisted of mortar laid on the old brickwork, specially quick-setting cement being used for this purpose. Pits 4 and 5 were then excavated and filled in solid with 6 to 1 Portland cement concrete, forming inverts. The shapes of the various pits are shown by the dot and dash lines.

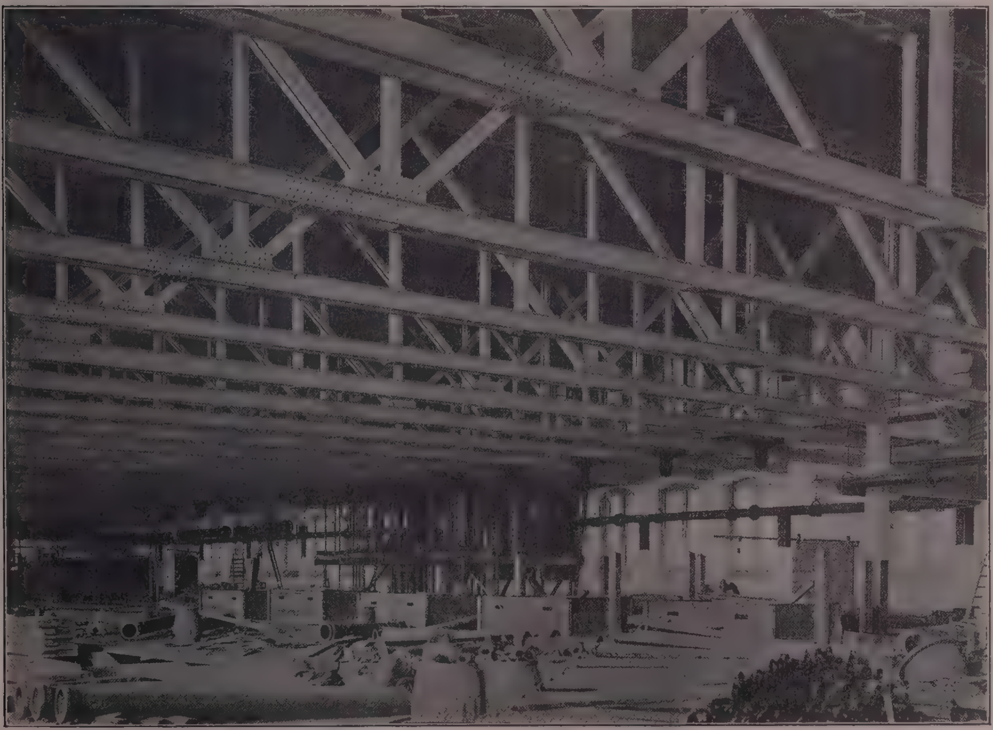
The work has been entirely carried out by the Works Department of the London County Council, under Mr. G. W. Humphreys, Mr. Maurice Fitzmaurice being chief engineer to the Council. The steel work was supplied by the Cleveland Bridge Company, of Darlington.

The Dye House of the Washington Mills, Lawrence, Mass.

The superstructure of the Washington Mills dye house of the American Woolen Co., at Lawrence, Mass., was so designed as to leave the floor space entirely unobstructed by columns and of such height as not to interfere with the placing of the necessary piping and shafting. Of special interest is the intermediate floor or ceiling introduced beneath the roof for the purpose of preventing condensation.

The main building is 529 ft. long by 111 ft. wide. A portion of the east end about 90 ft. long is two stories in height, while the remainder, exclusive of towers, has but a single story 30 ft. high. Foundations and sub-floor consist mostly of concrete piers, but rubble masonry with concrete base is also used. A granite underpinning extends around the building on all exposed sides.

The side walls are 3 ft. thick between windows up to the bottom of the trusses in the main or west portion, and up to the second floor in the east portion. Above this they are 32 in. thick to the intermediate floor or ceiling and 28 in. thick to the roof. Brick trench walls 1 ft. thick support machines, kettles, and other apparatus, in the main building. All main walls are of brick. Partitions are of 1¾ in. cement plaster.



Trusses Carrying the Intermediate Floor of the Dye House.

Section with Longitudinal Floor Beams.

The first floor is largely of regular mill construction with Southern pine timbers, 3¾-in. spruce floor plank and ⅞-in. oak top floor. The second floor at the easterly end and that over the office is of wood supported by reinforced concrete beams. The toilet room floors, the third floor in the easterly end and the entire intermediate floor, including beams, are of reinforced concrete.

The intermediate floor, which serves primarily as a ceiling, and is a somewhat novel feature of the design, is supported by a series of trusses spaced 10 ft. on centers. These span the entire width of the building—a clear space of about 108 ft. Their depth is 12 ft. 8 in., the bottom chords being about 17 ft. from the main floor. The bottom chord in each truss is made up of two channels back to back. Those at the ends are 12 in. 20½ lb., while those between are 12 in. 30 lb. The top chord is also of channel section, of the same dimensions. The channels in both cases are separated about 8 in. End diagonals are double 12-in. 20½-lb. channels. The upper chord and both end diagonals are latticed on top with flat 2¼ x 5/16-in. bars. All other diagonals are double angles 5 x 3½ x ½ in., except the two in the middle. The latter and all verticals are made up of double angles 4 x 3 x 5/16 in., reinforced by a ¼-in. plate in certain cases.

Resting on the trusses are reinforced concrete beams supporting the ceiling or intermediate floor. The reinforcement consists of loose square twisted rods. Upon each beam rest three 4-in. wrought iron pipe columns, one in the centre of the building and one intermediate on each side. These support the roof, the timbers of which are of Georgia pine spaced 10 ft. on centers. The roof plank is of northern pine 3 in. thick, covered with six-ply tar and gravel roofing.

The intermediate floor, which is designed for a live load of 75 lb. per square foot, is of concrete 6 in. thick at the walls and 5 in. thick at the center of the building. It is reinforced throughout by square twisted rods. The longitudinal reinforcement is spaced 6 in. on centers, the ½-in. square rods being laid 1 in. into the concrete from the bottom. The rods which run crosswise of the building are of the same size, spaced 12 in. on centers. Additional reinforcement is provided by ⅝-in. rods 5 ft. long, spaced 6 in. on centers, placed at right angles to the trusses and extending an equal amount upon either side. In the last bay at the westerly end, which is wider than the others, longitudinal reinforced concrete beams are also used as a means of support for the intermediate floor. Provision for expansion and contraction of this floor is provided by the breaking of joints at every third truss, thus leaving it in 30-ft. sections.

Reinforced concrete columns are used for supporting the second floor and roof in the eastern section of the building. They are spaced 10 ft. on centers in transverse rows of three each. All concrete in columns, beams and floor base is a 1:2:4 mixture, except that used around and under the lower rods of the floor beams. The mixture for the latter purpose was one part cement, one part sand and two parts of pea-sized crushed stone.

Heating is accomplished on the plenum hot-blast system by means of six sets of apparatus, each consisting of two lighter-driven fans with heaters. All apparatus is located beneath the main floor and discharge into a horizontal reinforced concrete duct built against the north wall. Pilaster flues spaced 20 ft. on centers along the north wall, which is protected by adjacent buildings, carry the heated air above head level whence it is discharged across the building toward the exposed side. The coils are ordinarily supplied with exhaust steam including that from the fan engines.

Four engine-driven exhaust fans are located overhead among the trusses. No piping connects with their inlets, but air is drawn directly from the building, the number of fans serving to give equable distribution and uniformity in ventilation. All fans discharge through the roof.

The shafting is made up in lengths of 20 ft., coupled together and suspended from the steel trusses in self aligning hangers. Wood blocks are interposed between all hangers and steel work. All shafting is driven by belted electric motors. Both live and exhaust steam is furnished for the dye vats and kettles. Exhaust steam enters through a 24-in. pipe from the engine room. Branch pipes therefrom in successively reducing sizes are carried through the trusses. Live steam from the boiler house enters the building at the extreme eastern end through a 10-in. pipe and is carried with its connections beneath the trusses.

Reducing valves are locally introduced in the live steam mains to permit of admission of steam at lower pressure to the exhaust steam system. All individual connections to kettles and vats are of brass.

The dye house was designed by Mr. Charles T. Main, mill engineer and architect, of Boston.

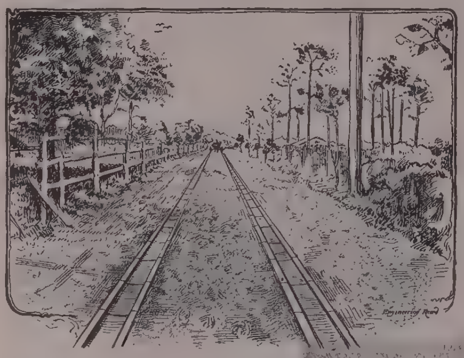
Letters to the Editor.

A Concrete-Block Track for Highways.

Sir: My experience of some twelve years as county commissioner has brought me face to face with the road problem in nearly all of its phases. In this particular section most of our roads are made of clay and sand, and while this makes a fairly good road when the weather is neither very wet nor very dry, yet when we have extremes of either of these conditions our roads are not what could be called "good" roads. When we have very wet or very dry weather all of our roads, both those entirely of sand and those of clay and sand, cut into ruts, and this makes the travel both slow and tiresome. This put the idea of a track-road in my mind, and, while the idea is not entirely new, yet I do not know of any road being made exactly like the one I shall describe. The whole idea is to make a hard rut for the wheels to run in, for a horse will travel in the ruts if left to his own way, and if taken out of a rut, as soon as he has his head again he will go back to the rut with the wheels, hence if we can get a hard surface for the wheels to run in the horse can take care of himself.

The block road that I have designed and made is constructed of cement and Florida sand in proportions of one-third cement to two-thirds sand. The block is 2 ft. long, 1 ft. wide and 8 in. thick at the thickest point. It is grooved in the center on each of the 12-in. surfaces, the groove beginning 2 in. from the outer edge and descending toward the bottom of the block in a convex curve to a depth of 1½ in. This convex curve, being about 1 in. wide and being made on either side of the block, gives a flat surface, 6 in. wide, at the bottom of the groove for the wheels to run in, and the flanges on either side of the groove hold the wheel in position. The blocks have a V-shaped tongue and groove arrangement on the ends to hold them in position. They are put into the ground, whether clay or sand (but clay is preferable), to the depth of the thickest part of the block, that is, when placed in position the flange should be flush with the general surface of the road. Most of the vehicles in this country have a 61-in. tread, and we lay the blocks 61-in. center to center. It is found that there is no difficulty in driving in and out of these grooves, either with a heavily loaded wagon or an automobile. We have put down a small section of this road in Orange County, and so far it seems to be all that is claimed for it, though doubtless time will demonstrate that improvements can be made in the blocks or the manner of laying them. The idea in making the blocks curved on both sides is that the curve on the bottom of the block holds it in position, and when worn the block can be turned over, and thus renew the road.

A few of the points that are claimed for this road are that it is good in either extremely wet or dry weather; it will not wash away, and when once made can be repaired at a minimum of cost. It is intended primarily for those sections of the country where road material is scarce. It will not wear out from the suction from rubber auto tires, as the macadam road does. It can be made and laid at a cost of from $1,500 to $2,000 per mile, and when made is as good for all practical purposes as a road that will cost from $5,000 to $8,000 per mile. Given the cost of labor and cement, one can calculate pretty close to the cost of the road in any section of the country. This block road, if laid in a sandy country, where the soil is sufficiently rich to grow Burmuda or some similar grass, will be found to be one of the least expensive of roads to keep in repair, for the grass will hold the blocks in position and will afford an excellent roadbed to turn out on when this is necessary.



A Concrete-Block Track in a Highway.

I should be glad to see this road tried in other parts of the country and shall be glad to correspond with any road builder who has an idea of trying it, and give him all the information I can.

The accompanying cut made from a photograph will give an idea of the road as it is laid. Yours truly,

H. H. Dickson.

Orlando, Fla., April 15.

Septic Tank Patents.

Sir: In a recent number of the Record I saw a letter by an engineer in regard to the septic tank decision recently rendered by the Court of Appeals for the Second Circuit. The tenor of this letter surprised me, but it seems to be no more than what one should expect from an engineer who confesses that he has induced others to install or pay for the installation of septic tanks and to use them. To my mind the actions of engineers in regard to the Cameron patent have been to the greatest degree reprehensible. They have taken bodily a part of the Cameron device and while being careful to keep within the law themselves, have misled others and induced some to make and sell a patented article and others to use a patented article. No engineer can plead in extenuation of his conduct that he did not know that it was claimed that the septic tank was covered by at least one patent, as that claim was widely advertised. I think it is greatly to be regretted that the mere designing and superintending of the construction of a patented device for the purpose of having others make, use or sell the device, is not a violation of the patent laws. The relation of an engineer to his client must of necessity be close and intimate, and the client must rely upon the knowledge of the engineer as to the particular art in which the engineer is serving him. And when an engineer submits as his own design that which he has taken bodily from a patent granted to an inventor and does not tell his client of the patent, he violates the confidence of his client and does that which cannot but be considered as bordering very close upon knavery. It must be remembered that the engineer submits the design as his own in order to earn a fee, and because of his own lack of knowledge or inventive ability he is unable to solve the problem submitted to him and thus earn his fee without appropriating that which belongs to, or at least is claimed by, another.

In the case of the septic tank, the very name was originated for, and applied to, a certain specific device by Cameron, and engineers over the country pretended to design, in order to get a fee, this specific device. There are, however, two extenuating circumstances as follows: First, the owners of the Cameron patent did not, so far as I can learn, publish in the literature sent out by them the name of the patentee or the date or number of the patent; second, until very lately it has been impossible to get from the Patent Office a copy of the U. S. patent granted to Cameron and his associates. It looks very much as if the owners of the U. S. Cameron patent had bought up all the copies of the patent printed by the Patent Office when the patent was issued and hence prevented the general public from acquiring a knowledge of the exact wording of the specification and claims of the patent.

I think that whether the decision does or does not stand, it will be of great benefit to the public by tending to make engineers give more heed to patents and patent law. And if the American Society of Civil Engineers does anything it should take some steps to discipline those of its members who induce innocent parties to violate the patent laws and thus subject themselves to heavy penalties, as the only gainers by such acts are the engineers who are paid money for what they do. The only cases in which an engineer can be considered morally free from guilt in such matters are when he notifies the client of the fact that he has used in his design that which another claims to have covered by a patent, and warns the client of the penalties to which the client may be subjected because of using the apparatus; or when the engineer submits a design for an apparatus for which he controls patents or for which he will be responsible.

Respectfully,

J. H. Kinealy.

St. Louis, Mo., April 15.

[The Engineering Record does not agree with the spirit in which this letter was apparently written. There is a considerable number of specialists in sewage disposal who honestly believe that the process covered by the Cameron "process patent" was used in this country and abroad before the construction of the Exeter septic tank. The law of the land encourages them to contest any contrary opinion. It is a fact that, almost without exception, American specialists in sewage disposal have not believed that the Cameron "process patent" was valid, and if they held this belief they were fully warranted in advising their clients to refuse to pay royalties. Mr. Kinealy is unquestionably right, however, in his contention that there has been a tendency to ignore patents relating to some features of engineering work.]

Artesian Wells are reported to have been successfully bored at Suwanee, Valencia County, New Mexico, on the Atchison, Topeka & Santa Fé Railway. All of the land in this region has heretofore been considered arid.

THE ENGINEERING RECORD
PUBLISHED WEEKLY BY THE
McGraw Publishing Company
James H. McGraw, Pres.
J. M. Wakeman, 1st Vice-Pres.
A. E. Clifford, 2d Vice-Pres.
C. E. Whittlesey, Sec. and Treas.

John M. Goodell, Editor.

MAIN OFFICES:
239 WEST 39TH STREET, NEW YORK.
BRANCH OFFICES:
CHICAGO: Old Colony Building.
PHILADELPHIA: Real Estate Trust Building.
CLEVELAND: Schofield Building.
LONDON OFFICE: Hastings House, Norfolk St., Strand.

SUBSCRIPTION RATES.
United States, Cuba and Mexico............$3.00 a year
Canada ....$4.50 a year
Foreign subscription......................$6.00 a year
25 shillings. 25 marks. 31 francs.
Foreign subscriptions may be sent to our London office.

NOTICE TO ADVERTISERS.

Changes in advertisements intended for a particular issue should reach the office of THE ENGINEERING RECORD on Friday of the previous week. New advertisements can be received up to noon of Wednesday of the week of issue.

NOTICE TO SUBSCRIBERS.

REMITTANCES.—Remittances should be made by check, New York draft, or money order, in favor of THE ENGINEERING RECORD.

CHANGE OF ADDRESS.—The old address should be given as well as the new, and notice should be received a week in advance of the desired change.

BACK COPIES.—No copies of issues prior to January, 1907, are kept on sale, except in bound volumes.

DATE ON WRAPPER indicates the month at the end of which subscription expires. The sending of remittances for renewal prior to that date will be much appreciated by the publishers.

CLUB RATE.—In acknowledgment of assistance rendered by subscribers in the securing of new orders, a club rate of $2.50 per annum is quoted. This rate applies to subscriptions in clubs of two or more, at least half of the names in the club to be those of new subscribers.

Entered at the New York Post-Office as Second Class mail matter.

Copyright, 1908, by the McGraw Publishing Co.

The circulation of THE ENGINEERING RECORD for 1907 was 763,000 copies, an average of 14,673 copies per week.

Of this issue 14,000 copies are printed.

TABLE OF LEADING ARTICLES.

Temperature Cracks in Masonry.................... 597
Subways in Chicago.............................. 597
The Production of Special Equipment.............. 598
Reporting Construction Methods to the Home Office.. 599
The Re-grading of Seattle, Washington, I. (Illustrated) 600
Heating Systems for Mills........................ 604
The New Blue Island Avenue Water Tunnel, Chicago (Illustrated) 605
The Power Plant of the American Biscuit Company, San Francisco, Cal.......... 608
The New Water Supplies for the Cities of the East Shore of San Francisco Bay (Illustrated)......... 609
A Hydro-Electro Development in Fork Canyon, Utah (Illustrated) 611
Bascule Bridge of the Rall Type at Peoria, Ill. (Illustrated) 613
A Window-Cleaning Traveler for the Carnegie Library, Pittsburg, Pa. (Illustrated).......... 615
Location Methods on the Natal-Cape Railway, South Africa (Illustrated) 618
Some Notes on the Boiler Blow-off (Illustrated)..... 619
Quick Replacing of a Double-Track Steel Span (Illustrated) 620
Reinforced Concrete Sewers in Wilmington, Del. (Illustrated) 621
A Small Concrete Dam (Illustrated) 622
Comparative Tests of Alcohol and Gasoline in Engines. 623
Book Notes 624
Operating Results with the Pittsburgh Filters........ 624
Garbage Disposal 624
Dustless Roads 624

Temperature Cracks in Masonry.

The views of engineers regarding the relative effects of changes of temperature on iron or steel and masonry when in combination, have changed much since the modern tall building has disclosed a significant experience through the changing temperatures of a considerable number of years. The usual building of this class, as a structure, is composed of the sustaining steel frame carrying the masonry curtain walls and floors, now frequently of combined concrete and steel. In the absence of suitable experimental data it was formerly supposed, by at least some engineers, that such a combination would not work harmoniously with the varying temperatures of changing seasons. On at least one occasion a prominent engineer making a public address gave a graphic picture of the disruptive writhings which would necessarily take place between the two classes of materials included in a modern high building by reason of thermal changes, and in consequence of which the masonry and iron frame would inevitably part company, thus ultimately destroying the building. Of course no such results have taken place but, on the contrary, concrete and steel as well as other masonry and steel or iron, expand and contract in complete harmony in virtue of a practically identical coefficient of thermal expansion and contraction.

There are other effects produced in masonry, however, by thermal variations of dimensions which frequently give the engineer more or less disquiet, especially in connection with high masonry dams. These effects are substantially the same whether the older class of heavy rubble masonry is employed, or the modern cyclopean concrete. This has been well illustrated by recent heavy masonry constructions in the Croton basin, both at the new Croton dam completed two or three years ago, and at the Cross River dam finished last autumn. At the new Croton dam, the construction of which was carried on with less speed, cracks were opened by the fall in temperature from summer or early autumn to winter while the construction of the upper part of the dam was in progress, but at the Cross River structure, where the masonry of the uncompleted dam was exposed during one winter only, no substantial cracking was noticed until the cold weather of the past winter produced separations of the masonry at a number of points after the work was complete.

In the April Proceedings of the American Society of Civil Engineers there may be found a paper on "The Effect of Temperature Changes on Masonry," by Mr. Chas. S. Gowen, M. Am. Soc. C. E., in which he fully describes the results of his observations on the cracks formed in the new Croton dam. It appears there were three principal cracks in the main body of the dam, and three others in the overflow. As would be anticipated, all these cracks were in the top of the dam, where the masonry is thinner than in any other portion of the structure, and they opened with the falling temperature of the late autumn and winter, as would naturally be expected. The greater part of the main dam is built of heavy rubble well and solidly laid so as to prevent seepage to the greatest possible extent. The widest crack was less than one-eighth of an inch. All of them extended through the mass of the dam at and near the top, but they ran out lower down. They were obviously capable of letting some water through, but the surfaces of parting of the masonry were necessarily rough and irregular, so that small quantities only could flow through.

In the Cross River dam there was one interesting feature of construction not found in the Croton dam. A considerable number of twisted square, and other deformed rods were laid in the masonry continuously from one end to the other for some distance down from the top of the structure for the purpose of reducing the temperature cracking as much as possible. No published accounts of the results of this experience at Cross River has yet appeared, but it is understood that about the usual amount of cracking took place. The exposure in this instance was, however, rather severe, as the work was practically completed in August and the reservoir is not yet full. Obviously, a full reservoir with the water covering the maximum amount of masonry surface on the up-stream side will modify materially the effect of the seasonal change in temperature. There is no question that the presence of steel rods distributed throughout a large masonry mass will reduce substantially the cracking that would otherwise take place, but how much such steel must be employed to prevent all cracking is as yet undetermined and it may be much larger than sometimes supposed. It is hoped that this initial experience with steel rods in the Cross River dam may be so used as to disclose valuable data on this point. It is clear that if steel rods are to be embedded in a mass of masonry for this purpose, much the greater part of it must be placed near the surface where rapid changes of atmospheric temperature are most liable to start the cracks; and it is further clear that such projecting parts as copings and cornices require relatively more metal than other portions of the mass.

At first sight cracks like those described by Mr. Gowen and which have occurred elsewhere, may seem serious, but extended experience has shown that such is not the case. The openings are always narrow in the interior mass and so sinuous with rough surfaces as to create much resistance to the flow of water through them. It is true that a well-defined, although very small, stream appears at the downstream face of the dam, but its discharge measures little in actual volume even in the coldest weather and hence when widest. They are easily stopped, nearly entirely, in a number of ways, as by the use of mortar, lead, wool or other means. When the cracks are filled with neat cement or cement mortar, the expansion of the next summer may crack or spawl off some masonry edges, but that is of no consequence. By thus filling the cracks wherever they open it will require but two or three seasons to secure an essentially continuous masonry mass needing little or no subsequent attention.

Some control of the effects of these thermal changes can be secured by laying the upper part or most exposed portion of the masonry in the late autumn or early winter, if the season permits, so that the fall of temperature to the lowest of the winter will be made the least practicable. Further observation and study of the effects of thermal changes in these great masonry masses will yield much-needed data.

Subways in Chicago.

A subway system designed to relieve the congestion of the streets in the central business district of Chicago has again been brought to the fore in a manner indicating that action regarding this much-needed improvement may soon be expected. In a recent message to the Chicago city council Mayor Busse urged immediate consideration of all the conditions pertaining to the design, construction and operation of underground railways, with a view of undertaking the work at the earliest possible time. This recommendation received the immediate sanction of the committee on local transportation of the council, and such unqualified approval of the local press and of the public generally that little opposition to the execution of a comprehensive subway plan is to be expected. The reconstruction and rehabilitation of the surface transportation lines has progressed with such rapidity and satisfaction that the consummation of this work is evidently merely a matter of time. The well-directed endeavor that is being made by the municipal authorities to co-ordinate the four lines of the elevated railway system and to increase the capacity of that system will also apparently produce early results. Even when these various extensive improvements to the existing transportation facilities have been made, the streets of the downtown business section will remain badly congested without considering the great annual increase in traffic which is definitely certain; and this congestion can only be relieved by handling a large portion of the surface cars underground in this dictrict.

Every feature of the local transportation situation in Chicago has been so thoroughly analyzed that the only additional investigations necessary relate to the arrangement, design and construction of the parts of a subway system. The extensive study of the existing transportation conditions made in 1902 by Mr. Bion J. Arnold resulted among other things in two proposed general plans for handling traffic underground in the congested business district. The rebuilding of the surface lines is being carried out practically as suggested then by Mr. Arnold, and will increase the capacity of these lines to a remarkable degree. The manner in which the cars of most of the street railways of the entire city are brought from three directions into the comparatively small central business district, in which the streets are already badly crowded with other traffic, renders immediately imperative, however, the removal of these cars from the surface in that district.

The general conditions governing the design of the two subway plans proposed six years ago by Mr. Arnold to meet this requirement have not changed enough to alter these plans. One of the latter contemplates the construction of a subway directly under the street surface to handle the cars from the North and South side lines, while most of the West side cars would be brought into the business district as at present. This arrangement would permit the successful operation of a combined surface and subway system, but is open to so many objections that it has never been considered a solution of the problem. The other plan would involve a larger outlay than would be entailed by the first, but it permits the desired conditions to be obtained in an ideal manner. This second plan requires two systems of underground loops in the congested area; one directly below the street surface to serve the North and South side lines, and the other immediately under these for the West side cars, but no one street having subways of both levels except at intersections. The second plan has been universally approved, and since many of the unfavorable contingencies governing its adoption are set aside by the ordinances controlling the operation of street railways that have become effective since this plan was first proposed the latter is conceded as the one that will be chosen. Even with this ideal plan a few surface cars will in any event necessarily be operated to handle short-haul traffic and passengers for points not reached by the subway loops.

The complete rearrangement and reconstruction of the sewers, water-distribution mains and public service conduits in the business district is proposed in connection with the building of the subways. The water mains and the sewers in this district remain as they were rebuilt shortly after the fire, with the result that their capacity is about equal to the needs of a village covering the same area. The space immediately under the street surface is also completely occupied by conduits for electric cables, gas pipes and so forth. Fortunately, the streets are wide enough to permit the construction of conduits on both sides of the subway structures for all of the service mains that may be required for many years. The subway plans also contemplate the provision of a separate high-pressure system of water mains for fire protection, of adequate distribution mains for ordinary purposes and of both high and low-level sewers. As the conduits and pipes will all be arranged with entrance manholes, the street surface will rarely, if ever, have to be disturbed after the subways are completed.

The construction of the subways as proposed involves no engineering difficulties that cannot be overcome at a reasonable cost. The excavation to a depth of 10 to 14 ft. from the surface will be through materials that were used to raise the grade of the city after the fire. Under this fill is a deep bed of blue clay ranging in character at various depths from material the consistency of soft putty to hardpan over bed-rock at a depth of 90 to 110 ft. This clay, to a depth of 40 to 60 ft. from the surface, flows under pressure when not confined. The great system of nearly 60 miles of freight tunnels that have been driven through it under all the downtown streets at depths of 35 to 50 ft. below the surface have been completed, nevertheless, without the payment of any damages to adjacent property. Recent open-cut operations have also been carried to depths of 40 to 45 ft. below the surface close to high buildings founded on the clay by the use of long steel sheet-piling without injuring these buildings in any way. It is therefore reasonable to believe that with care the subways may be built so none of the abutting structures will be damaged to any serious degree.

The presence of the existing system of freight tunnels will also permit the spoil from the excavation to be handled without bringing any of this material to the surface. In fact, the spoil from practically all of the large excavations that have been made in the downtown district in recent years has been thus handled, as noted at various times in this journal. The major part of the materials of construction may also be delivered through these existing tunnels. The plan has been proposed to drive the lower-level subways first as tunnels and to finish their construction before the street surface is disturbed. The high-level subways could then be built in open cut and most of the latter covered to avoid interference with street traffic, since the spoil could be removed from the cut and construction materials delivered to it by means of the freight tunnels. In this manner, the construction may be handled with much less interruption to traffic than has been occasioned by any similar work thus far undertaken.

The cost of the comprehensive subway system which is favored is estimated to be $30,000,000, a great sum to be raised by Chicago as limited by its present misfit charter. An annual income to the city of nearly $1,500,000 from the street railway companies is available under the new traction ordinances, and other special funds are to be provided for subways by those companies under the same ordinances. Changes in the State laws limiting the bonded indebtedness of the city are also under consideration. These various means are held to collectively offer a sufficient source for raising the necessary amount. In case these means prove inadequate, local public sentiment is apparently so strongly in favor of the construction of the subways to complete the traction plans, with which such marked success has been attained, as to assure support for any legislation that may be necessary to permit the city to raise the additional funds required.

The Production of Special Equipment.

One of the most important questions which the manufacturer of standard machinery has to consider during a period of rapid progress in any special industrial field is the production of special equipment at a reasonable profit. When an establishment is devoted largely to the production of a standard line of machinery, where special tools have been developed and installed at great expense for the cheapest possible production of every part, and where the individual workman has become a specialist in the performance of a single operation, the temptation to push the sale of fixed types of apparatus under wide conditions of service is almost irresistible. There must be a broad market for the product of such a concern before standardization can be carried to the most profitable pitch, but in the older communities this is precisely the kind of demand which has been so long enjoyed by the manufacturing companies. The danger is that the manufacturer will adhere too long in specific cases to the exploitation and sale of equipment that remains from year to year unimproved except in minor details.

An illustration of this tendency to crystallize around a settled, conservative practice may be cited in the use in New England of the exceedingly moderate potential of 13,000 volts or thereabouts in the longer power transmissions in that section of the country. Just why no recent work of magnitude has been designed for the perfectly practical pressure of 25,000 to 40,000 volts or even higher is difficult to explain, but experience with extremely high potentials in the far West, in the Southern Appalachian region and Middle States shows conclusively that the present upper limit so generally considered as the extreme of daring in New England is a very ordinary potential in other parts of the country. With all due respect to the brethren of the Northeastern seaboard, it sounds a little funny to hear potentials of 2000 to 2300 volts frequently referred to in conversation as "high-tension power," when the transmission engineers of the larger sections and greater distances are dealing with 80,000 to 100,000 volts as the practice of the immediate future. The New England climate is certainly no worse than the salt fogs of lower California, and while the distances are short, there are plenty of cases where the power transmitted is carried over much longer stretches of country than are most efficiently served by currents at 13,000 volts. This journal does not pretend to prescribe the line voltage that should be used in transmission work as a standard for any section of the country, for that is the province of the consulting or advisory engineers of the power organizations, but the constant adherence to any single practice under a great variety of conditions indicates that too much reliance is being placed by some one on one potential, one make and type of railway motor, or one form of lamp as the most economical for a wide range of service. There is no single cure-all for engineering problems in which dissimilar conditions flourish luxuriantly.

Whether the purchaser makes the wisest choice or not, the manufacturer can powerfully promote the progress of specific industries by being more willing to furnish special apparatus in cases where its use would clearly be by far the best solution of the problem in hand. In the last few years there has been much improvement in this respect in this country. The choice of equipment in the last analysis rests with the purchaser, the problem in front of the manufacturer being how to produce new or highly improved equipment without sacrificing his legitimate returns. This means that it is fair to charge enough for new types of equipment to cover in a reasonable time the cost of development, protection, manufacture and sale, and it is better that the price shall be high at first, as long as the new apparatus pays for itself in the service of the consumer, than that the price shall be too low to reimburse the manufacturer for his expense plus a fair profit before such a large volume of the equipment is sold that it must be applied to cases in practice to which it is not wholly suited.

Economy in the production of special equipment calls for minimum interference with the factory output of products previously standard. If this class of work can be handled in a separate department, the establishment is surely fortunate. Sometimes the repair department or the branch of the organization responsible for all around adjustments and special assembly can be given supervision of new types of equipment, but in the great majority of cases, probably, the new apparatus must take its turn as best it can through the different shops, with handling and machining, assembly and test by the regular force of the plant. Thorough inspection of materials, even more careful selection of component parts than is practised in the case of a standard machine, closer watch of the behavior of the stock under the stress of tooling, and the use as far as possible of standard templets, jigs, tools and patterns help to reduce the cost of special equipment.

Reporting Construction Methods to the Home Office.

The handling of an important engineering job at a considerable distance from the home office of the organization in charge of the work calls for careful planning and thorough reports of progress if the project as a whole is to be successfully completed. The firms of engineers whose reputations are of world-wide extent have found it necessary in the design and construction of important works to pay a great deal of attention to these reports and to file them according to special methods. In some cases, however, there has been so much attention given to the preparation of correct working plans and drawings and to the weekly or monthly reports of the progress of the work that the very important matter of suitably recording the particularly successful or difficult methods of construction used in the field has been almost entirely overlooked.

In practically all cases of this kind the resident engineer is well acquainted with the details of the solution of each construction problem on the ground, and it is often the case that the photographs sent to the home office to illustrate the progress of the work will show some of the ingenious methods which had to be developed to meet the emergency of the occasion in the field. These points are well worth saving in an organization which is handling all sorts of problems, and if the resident engineer can be induced to forward with his photographs, or at least with his routine reports, a brief but accurate note of the construction method followed in the illustrated case, the home office will be placed in possession of valuable information. The photograph may show the scheme, but in a good many cases some word of explanation is essential to make the record valuable to other members of the staff. To urge that such notes need not be made because the resident engineer can be called upon for the necessary explanation when he returns, is to place the organization in a position of dependence, and it is not too much to say that it is quite as important to keep track at the home office of the special ways of overcoming difficulties in the field as it is to have an accurate report at weekly intervals of the number of Finns who dined at the company's table-de-luxe in the front of Box Car 999 in the excavation of section 10. The constant aim of a great engineering organization should be to give all the members of the staff an equal opportunity to benefit from each other's experience.

Notes and Comments.

A Typhoid Fever Survey to determine the means, aside from domestic water supplies, by which this disease is transmitted is to be conducted in Pittsburg at the expense of the Russell Sage Fund. The introduction of filtered water to the city ought to permit other sources of infection to be traced readily.

The Opinions Regarding Water Rights held by the President are evidently to be questioned in the United States Senate, for on April 30 the Senate Committee on Commerce reported favorably a bill authorizing the construction of a dam across the James River in Missouri, without the amendment recommended by the War Department which provides that compensation must be made to the Federal Government for the privilege of constructing this dam. A few weeks ago the President vetoed a somewhat similar bill concerning a dam across the Rainy River in Minnesota, on the ground that every permit to dam a navigable stream should specifically recognize the right of the government to fix a term for its duration and to impose such charges as may be deemed necessary to protect the present and future interest of the United States. The message containing that veto indicated that the President proposes to veto all bills of this nature. Senator Nelson, of the Committee on Commerce, prepared an elaborate brief to show that the President had no authority to take this position, and the action of the committee indicates that it is of this opinion. It is a foregone conclusion that the President will veto the James River dam bill and it will then be seen to what extent the opponents of the President are prepared at this time to carry their opposition to his determination that all grants of rights must be coupled with provision for compensation and federal supervision.

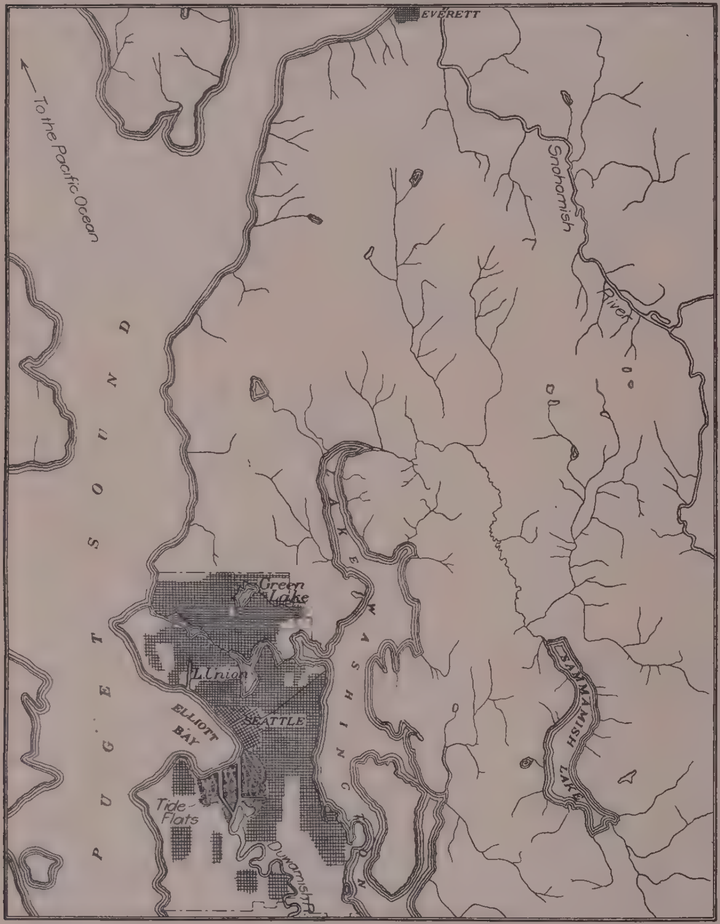
The Connecticut River Bridge at Hartford, over which traffic is now and has been passing since November of last year, is one of the most attractive stone structures in this country, and for this reason the reports that cracks have appeared in several parts of it have attracted considerable attention. As a matter of fact, there are no cracks in the bridge proper, save such as are apt to occur in the pointing due to temperature cracks that must be expected in nearly a quarter of a mile of continuous masonry. The piers for the bridge are all founded on rock, except that of the east abutment, which is heavily piled, and all of these piers may be regarded as solid as they can be made by modern engineering. Cracks have developed, however, in the easterly north wing wall, a continuation of the last arch spandrel wall, despite the precaution taken to excessively load the wall before the coping was put on, which has held nearly two years without developing any crack in the wall. There is no theory at which the engineers can arrive to account for the bad crack opening up after completion of the work. This wall has a separate foundation from that of the abutment, on sufficient piles, cut off about 8 ft. higher than those in the abutment. It is a matter of no serious moment, being simply a wall less than 50 ft. long, and at worst can be readily relaid without affecting the bridge, with which it has nothing to do. On the west side, high retaining walls flank the abutment on either side of it, and at right angles thereto; the north flank is not yet built. The south flank is entirely a separate structure from the bridge, the abutment of which is on rock. The wing wall is on piles, and a so-called crack shows up between the wall and the abutment, between which there is no bond, as there never should be between a pier and a wing founded on different bottoms, or with different pressures. The separation crack between this wall and the abutment is a mere matter of repointing when convenient.

The River Gaugings conducted by the U. S. Geological Survey are again threatened with complete abolition, for the sundry civil appropriation bill recently reported to the House contains no appropriation whatever for the work. The value of these gaugings is so great in connection with irrigation, power, flood prevention and water supply enterprises that the continuation of the work is very desirable. A break of a year or more in the records of stream flow would be particularly unfortunate, for it is only by a study of consecutive gaugings covering many years that safe estimates for great engineering undertakings can be prepared. Every engineer acquainted with irrigation and power works can cite cases where large sums of money have been wasted on account of insufficient information regarding the seasonal and annual fluctuations in the discharge of rivers. Now that it seems likely those who receive federal grants for water rights of one sort or another will be required to compensate the government for these privileges, there is still further need for carrying on the gaugings. The remarkably low cost of the gaugings, the excellent organization for doing the work, which has been developed only after years of experience in selecting and training the observers, and the general willingness to assist in furnishing data evinced by engineers and riparian proprietors would be largely undermined by a failure to make the necessary appropriations for even a year. The same fate threatens the fuel testing and structural materials testing conducted by the Geological Survey, for the appropriations in the bill for such investigations are so small as to be wholly inadequate for any real progress. The National Advisory Board on Fuels and Materials is practically abolished by the bill, for it contains no appropriations whatever for its expenses. Its members have never received any compensation for their services, but their traveling expenses have heretofore been paid. In view of the great value and extraordinarily low cost of the work done by the hydrologic and technologic branches of the Geological Survey, it is to be hoped that Congress will not curtail it in the manner proposed by the bill.

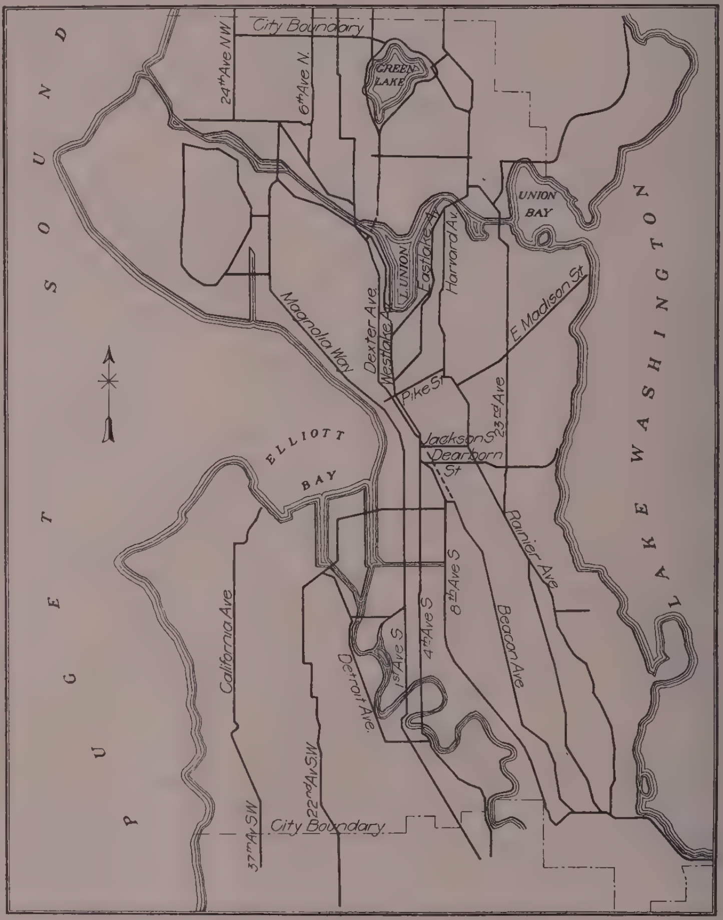
The Unfortunate Wording of a section of the contracts for New York barge canal improvements advertised last summer was referred to in this journal on July 27, 1907. Section 29 of the contracts in question read as follows: "The State Engineer shall, between the first and fifteenth days of each month, make and file with the Superintendent of Public Works, an estimate of the amount, character and quality of the work done and of the material which has actually been put in place in accordance with the terms and conditions of this contract during the preceding month and compute the value thereof. The Superintendent of Public Works *may* within 15 days thereafter, at his office in the city of Albany, N. Y., pay to the contractor from the money which shall have been appropriated for that purpose a sum not to exceed 90 per cent. of the value of the work performed and material furnished as so certified by the engineer—retaining not less than 10 per cent. thereof until the contract shall have been completed and approved by the State Engineer and Superintendent of Public Works." As was pointed out in this journal at the time, the use of the work "may" reduces the contract to a mere gamble, and possibly destroys its legality for want of consideration. Taking the clause literally, whether or not the contractor received his money would depend upon the whim of the Superintendent of Public Works, as there is no law to compel him to pay, nor any contract provision, and only a suit in equity, assuming one to be possible, would give the contractor relief from an official who was disposed to withhold money from the contractor until the latter had seen the right people. It is gratifying to learn that the Superintendent of Public Works has succeeded in having this clause in the terms of the contract changed. The Attorney-General has rendered an opinion that the Superintendent of Public Works may lawfully contract to do those things which the statute expressly says he may do, and that he may therefore contract that he will pay; and that further he will approve contracts in form if the word "will" is substituted for "may" in the payment clause. It has therefore been decided to make this change in all pending contracts. The elimination of this source of trouble is to be commended.

THE RE-GRADING OF SEATTLE, WASHINGTON.—I.

The re-grading of the site of Seattle, Wash., which has been in progress for several years, has already involved the moving of tremendous quantities of materials and the complete reconstruction of a large portion of the city. The work that has been done and that now is under contract to be completed in the comparatively near future give, however, only a good start in the prosecution of definite plans for ultimate grade-reduction that will doubtless be executed in the next few years. The work already completed renders the project, nevertheless, one of remarkable magnitude, and so greatly improves the former conditions that it is to be questioned whether the city would have reached its present proportions if this work had not been undertaken. While the topography of the site of the city was such as to necessitate the extensive work that has been done, in order to provide for immediate growth, the execution of the broad, comprehensive plans for the extension of this work will be equally necessary to permit the city to grow in the future in a manner that is most advantageous to the great metropolitan district that will unquestionably be centered on Puget Sound. Indeed, this work will be absolutely required before a suitable location for such a district can be provided.



Outline Map of Seattle and Vicinity.



General Plan of Arterial Highways.

The geography of Seattle and vicinity is shown in an accompanying map, which also shows various topographic features of the region on the east side of Puget Sound. Seattle is located on a long, narrow strip of land, with Puget Sound on one side and Lake Washington, a large body of fresh water, on the other side of this strip. The entire site of the city was formed by two great glacial movements. The first of these movements swept across the site into the Sound and left a comparatively small amount of material; the second appears to have terminated at various points in the strip of land on which the city is built, where it formed great, irregular terminal and lateral moraines. These immense moraines rise to considerable heights above the level of the water in the Sound, and are more or less generally parallel with the shore line of the latter. The bottom of the Sound drops away quite abruptly from the shore line to great depths in places within a few hundred feet of the shore. The site of the original part of the city was a series of steep hills that rose almost directly from the edge of the water. The city has extended over these first hills into the valleys and hills beyond to Lake Washington on the east, and for considerable distances toward the north and the south. The city faces directly on Elliott Bay, an arm of Puget Sound; and a great area of low land along the south end of this bay, that was formerly submerged by the tide, is also being reclaimed in connection with the grade-reduction work that is now in progress. This low area, which adjoins the business district on the south, will thus all eventually be made available for business purposes.

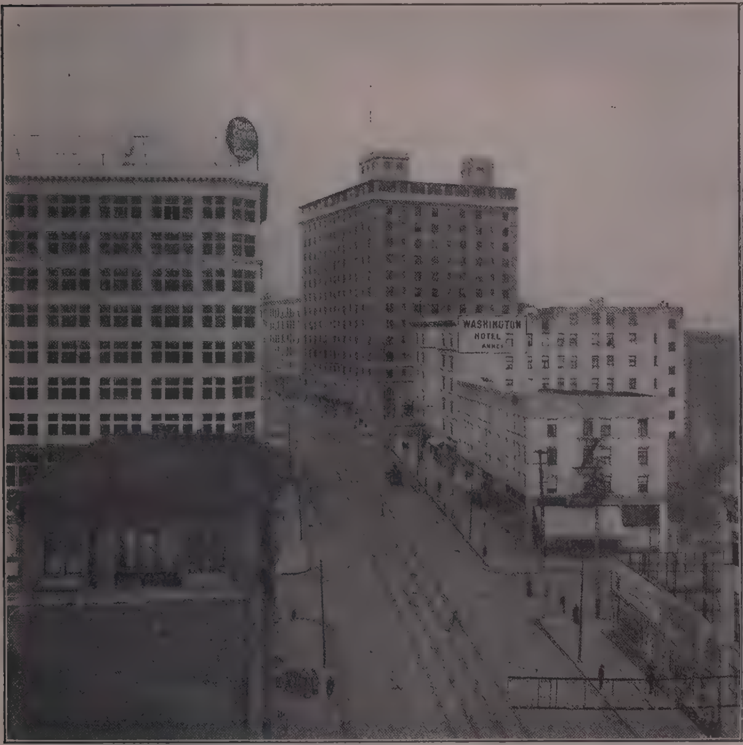
Lake Washington, in the rear of the strip of land on which the city is located, varies in width from 1 to 4.5 miles and has a total length of about 26 miles, with its long axis about parallel with the shore line of Puget Sound. This lake is of considerable depth over its entire area, with occasional pockets from 150 to 250 ft. deep, the present surface of water in the lake being 22 ft. above mean-tide level in the Sound. Toward the north end of the city is Lake Union, another body of fresh water that covers an area of about 960 acres and has an irregular shore line. This lake has its water level 13 ft. above mean tide, or 9 ft. below the level of Lake Washington. The general Government proposes to build a canal, 80 ft. wide on the bottom and with a depth of 36 ft., to connect Lake Washington through Lake Union with the Sound. This canal will reduce the level of the former lake to that of the latter and will open for commercial development the entire shore line of the larger lake, besides providing a most desirable anchorage for sea-going vessels.

The growth of the manufacturing, wholesale and central business districts of the city may thus be expected to extend along the shores of Lake Washington and Lake Union, as well as along the Sound and over the reclaimed tide flats. Provisions must therefore be made for easy access between these various districts. At the same time, the great growth of the city will necessarily be toward the north and the south, owing to the shape of the narrow strip of land on which the city has been started. The topography of the site of the city and, in fact, of the entire region on the east side of the Sound, is also such that arterial highway connections between the different sections of the metropolitan district that may reasonably be expected to extend for many miles in both directions from the present business district of Seattle must have a general northerly and southerly direction. This general requirement is not only brought about by the direction of the shore lines of the Sound and of Lake Washington, but also by the fact that practically the only level areas in the entire surrounding region are in river valleys which extend from the north to the south, or the reverse.

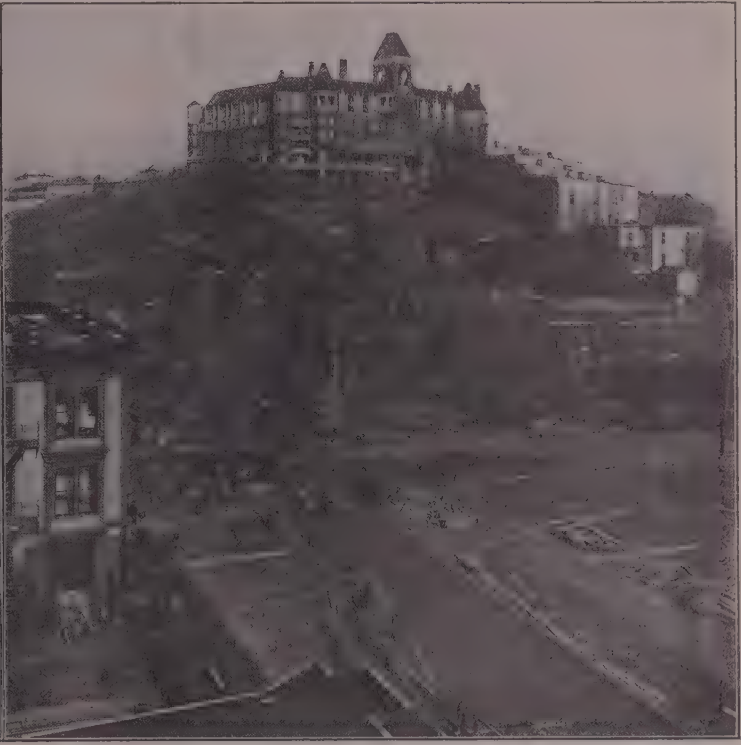
Governed by these topographical and geographical conditions and by confidence in the future of the city and surrounding country, a broad general plan for the re-grading of the site of the city has been developed by Mr. R. H. Thomson, who has been city engineer of Seattle for the last sixteen years. This plan first provides for the almost complete reduction of the steep, irregular hills on which the city was started, so the entire areas in which these hills are located may be rendered available for business buildings, whereas formerly most of the land in these areas was too steep to be used for business purposes. This re-grading of the hills provides material to reclaim all of the great tide-flat area at the lower end of Elliott

Bay and immediately to the south of the present business district. The second principal object of the general plan is to provide broad streets with easy grades in the districts re-graded, and to connect the different parts of the city by means of great arterial highways, which will for the most part be extensions of these streets. Such streets and highways must necessarily extend in a northerly and southerly direction, for the reasons explained, and can be connected at various intervals by cross-town streets on grades that will be low. In almost all cases, also, the grades of the cross-town streets will be reduced from those existing at the time the work was started.

The cost of the work that has been done and the extent of the plans to be carried out in the future are of specially great magnitude to have been undertaken by a community of the size that Seattle was at the time the first work was done. The remarkably direct and immediate benefits resulting, without exception, to the property in the areas re-graded have, however, rendered the work thus far finished justified beyond any expense that has been involved. The work that is now under way will also unquestionably produce at least equally good results. At the same time, the execution of the entire plan is likewise as essential to the future growth of the city as is that work which has been completed, and it may be expected to benefit the property and financial interests concerned in the same proportion as has that already done.



Second Avenue at Pike Street after Completion of Re-grade.



Second Avenue at Pike Street before Start of Re-grade.

The present retail-business and office-building district of the city is directly north of the low area that was originally submerged during high tide. This district was formerly on the steep slope of a hill that rose abruptly from the waterfront to a height of between 250 ft. and 355 ft. at a distance of from a quarter to a half-mile from the shore, most of the east and west cross-town streets having maximum grades of 18 to 22 per cent. The main business thoroughfares were consequently parallel to the shore line, but these thoroughfares were also on heavy grades in many places, since the side of the hill ascended rapidly from the south toward the north, as well as to the east from the shore line of Elliott Bay. At the top of the hill in the rear of the business district is a comparatively broad, level plateau that slopes toward a valley on the opposite side of the hill from the Sound, and toward lower ground at both ends.

The business district was confined at the end opposite from the tide-flats by a very high, isolated terminal moraine, with specially steep sides, known as Denny Hill. This moraine sloped away in all directions, but was originally connected with the hill in the rear of the business district in such a way as to practically shut the latter off from the lower areas around Lake Union and from a broad plateau between that district and the country toward Lake Washington.

The tide-flats at the lower end of the present retail-business and office-building district covered an area of between 1,500 and 1,800 acres, which was submerged with from 8 to 16 ft. of water at high tide, although largely exposed during low tide. At the rear of these flats a terminal moraine, generally parallel with the shore line and known as Beacon Hill, rises almost directly on very steep grades from what was originally the edge of the water at high tide to a height of 315 to 335 ft. above tide. Beacon Hill also connects with the hill in the rear of the business district, so the latter was confined to the steep sides of the hill on which it was started, with no opportunity for extension, and with little chance for the construction of satisfactory business buildings, or proper means of communication with other parts of the city. On the other hand, no sufficient space was available for a wholesale district, or for railroad terminals and switching facilities.

The first part of the re-grading to be done contemplates the removal of the limitations which were presented to the central business district by the original topographical conditions. It will also provide remarkable opportunities for a great wholesale and manufacturing district and for railroad terminal facilities by the reclamation of the extensive area of tide-flats within easy reach of the center of the city. These results will accomplish much toward the establishment of the plan for the great arterial highways that are proposed to connect the various parts of the city and to provide means of communication with all of the surrounding country. The portion of this first part of the re-grading to be done is practically finished within the central business district, and work is now under way in the areas immediately adjacent to that district. The contemplated additional grade-reduction work is in areas surrounding those in which operations are now in progress, and along the north and south arterial highways that are to connect the various sections of the city by easy grades.

The re-grading of the hills, in general, involves the removal of the material in the latter to the tide-flat area at the lower end of Elliott Bay. Much material has, however, been carried out into deep water in the Sound, where the excavation to be made is isolated from the tide-flats or from other low areas to be raised. Considerable quantities have also been used to bring low areas between the hills up to elevations that will render these areas available in connection with those already graded, or to assist in the general plan of grade reduction and of the provision of the arterial highways. The plans for the work still remaining to be done contemplate the same distribution of the materials from the hills that has already been followed.

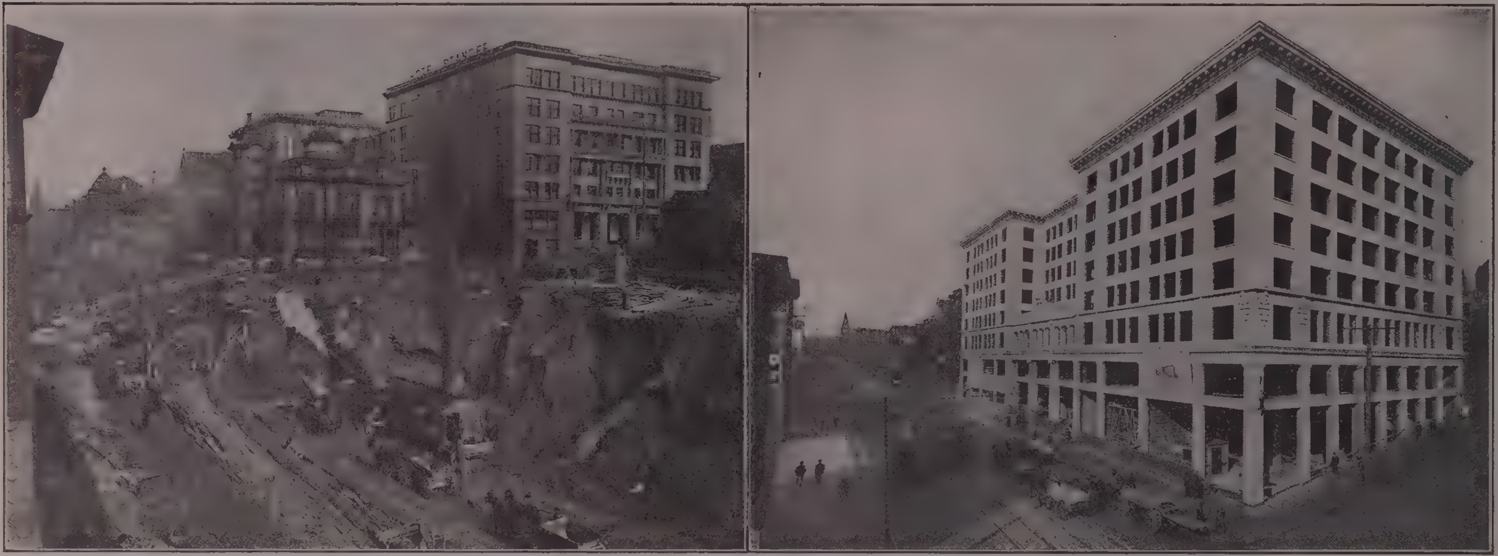
The re-grading is done in districts in which the cost of cutting or of filling the streets is assessed against the abutting property. In cuts, slopes of 1 to 1 are allowed on both sides of the street back from the property lines; in fills, slopes of 1½ to 1 are allowed on both sides, the cost of the cut or fill, as the case may be, being met by the property fronting on the work. The damages to the property in excess to the benefits, if such damages occur, are assessed against property not in the district that is benefited by the improvement. A standing court commission authorized by law levies assessments on the property benefited to pay the damages to the other property. The money to meet the cost of the improvement of the streets is obtained chiefly by local improvement bonds, which are in small denominations arranged so as to mature about 20 per cent. of the assessment each succeeding year after the completion of the work. The city also provides a certain amount each year from a general fund. The districts are formed according to the same general plan that is followed in the formation of any district for local improvements where the cost is assessed against the abutting property. Work is not ordinarily undertaken in any district, however, until a petition from a majority of the property in that district has been presented to the city council.

The work on private property outside of the limits reached by the prescribed slopes on the excavation or fill required to bring to grade the street on which the property abuts is paid for by the individual owners under a contract entirely separate from the one providing for the street grading. The private work, however, is usually done by the same contractor who does the street grading, the cut or fill in an entire area being made at the same time.

General Plan of Street Grades.—The grades of the first street along the water-front, Western Ave., have not been improved as yet adjacent to the retail business district. Plans for the improvement of this street have, however, been adopted, and will be carried into execution in the near future. At present this street has undulating grades varying from 4½ to 11 per cent., which grades are to be reduced to a maximum of 2 per cent. The width of the street is also to be increased from 66 ft. to 75 ft. at the same time. The presence of a large number of permanent buildings and improvements along this street will necessitate an extensive amount of reconstruction, in addition to the re-grading that will be required to carry out the plans which have been adopted. The grades of the next five parallel streets back, First, Second, Third, Fourth and Fifth Aves., have been, or are being greatly improved and the streets considerably widened. The business district is now confined chiefly to the first two of these streets, although it will doubtless eventually be extended to the other three. Third Ave. has, in fact, already been considerably built up with substantial buildings since it was improved. First and Fourth Aves., together with Sixth Ave., are being extended across the tide flats to the south at grades which will enable traffic from the reclaimed low land to reach easily the higher ground and hills to the north of that land. First and Second Aves. have been extended through Denny Hill to the north of the business district and the extension of Third Ave. through that hill is now under way. Fourth Ave. is to go through this hill, at a point where the maximum cutting is over 100 ft., and the extension of Fifth Ave. will also require an extensive amount of material to be removed from Denny Hill.

The original grades of these five main business streets, where the latter had been cut through the hills, varied from 5 to 22 per cent., and in most cases followed the undulations of the hillside on which they were laid. With the new arrangement these streets will all five have uniform grades of 3 per cent. against north-bound traffic, except on a portion of First and Second Aves., where it appeared to be impracticable when the reduction of these two streets was undertaken to reach the maximum grade established on the other streets. At the worst points on First and Second Aves., however, the maximum grades are 4.92 per cent. The disadvantage presented by the apparently unavoidable grades in this case in excess of the normal for the other improved streets is almost entirely offset by the conditions that have been obtained in subsequent improvements.

The steep directly from the water-front was so great as to prevent the satisfactory reduction of the grades in the cross-town streets connecting the five north and south streets which are being improved. Nevertheless, the grades of these cross-town streets have been, or are being materially lowered, and in most cases changed, so instead of following the undulations of the steep hillside they rise at a uniform rate, except at street intersections. Low-grade cross-town streets have also been obtained at both ends of the hill directly back of the business district, which enable the top of this hill to be reached over these streets by heavily-loaded vehicles, while carriages will be readily able to go up most of the remainder of the cross-town streets leading from the business district to the top of the hill.


Third Avenue Re-grade in Progress, 1906; and after Completion in 1907, from the Same Point.

The distribution of grades is, therefore, such that a long, wide, central area having five low-grade north and south streets is made available for a central business district by the work already done, or now under way. The main thoroughfares of this district will be connected at intervals also by cross-town streets having low grades, while the grades on the rest of the cross-town streets will be much improved over those formerly existing, and in many cases fairly acceptable for heavy traffic. The hill in the rear of this area will, at the same time, be rendered desirable for the location of large apartment hotels, a number of which have already been erected on it, and for residential purposes.

The broad area of low land to the south of the central business district will have the three low-grade streets, First, Fourth and Seventh Aves., carried up to new grades to provide an outlet to the north of it. A wide highway, with easy grades, is also being carried along the base of Beacon Hill, generally parallel to these three streets. The four main north and south highways thus formed will be connected in this area by low-grade cross-town streets, so that communication between the different parts of the reclaimed area will be easy. One of the principal cross-town streets in this area, Dearborn St., is also to be extended through Beacon Hill on a grade of less than 2 per cent. into Rainier Valley beyond this hill. This valley extends almost straight north and south, forming the natural drainage outlet for over 14 square miles of territory within the city limits. Rainier Ave., an 80-ft. highway already extending down it, will be widened to 90 ft. and also reduced to a maximum grade of 2 per cent. against north-bound traffic, south of the connection with Dearborn St. A great area of country to the south of the latter street in Rainier Valley that is now almost undeveloped, owing to the excessive grades which isolate it from the central business district, will thus be rendered accessible to that district on low grades. A low-grade connection between the Rainier Ave. and the shore of Lake Washington can also be made readily, so all of the district adjacent to that lake will have a direct entrance into the central business district. At the same time, the grades of that part of Rainier Ave. to the north of its connection with Dearborn St. are to be reduced to a maximum of 5 per cent. against north-bound traffic, which will enable the hills back of the business district to be reached from the rear. Jackson St., one of those cross-town streets extending east out of the reclaimed area, about a quarter of a mile to the north of Dearborn St., is being cut through Beacon Hill, so it will present a maximum grade of 5 per cent. to the traffic bound to the top of the hill back of the business district, or into Rainier Ave.

The general plans contemplate the connection of the northern end of the business district with the shores of Lake Union by several wide arterial highways built on low grades. Westlake Ave., the first of these highways to be completed, extends diagonally from the business district on a descending grade of 3 per cent. to the lower levels along the west side of the lake. This street crosses a semi-business and light-manufacturing section, through which it was cut by condemning the property required and by removing a great number of buildings and improvements. Dexter Ave., with a width of 90 ft., will be extended on 3.25 per cent. maximum grades, a short distance to the west of Westlake Ave., and at a higher elevation than the latter, to a broad area of rapidly developing country to the northwest of the lake, from which area it is now impossible for traffic to reach the center of the city. Magnolia Way, with a width of 90 to 100 ft., and maximum grades of 3.25 per cent., will be extended from the central business district to this same area by a route following around the side of several steep hills between Lake Union and the Sound. The districts on the east side of Lake Union will be made accessible to the central part of the city by means of Eastlake and Lake View Aves., corresponding respectively to Westlake and Dexter Aves. on the opposite side of the lake. The areas on the steep, and at present almost inaccessible hillsides which rise abruptly almost from the edge of the east shore of the lake, will be connected to these main highways by low-grade diagonal streets.

Construction Work.—The difficulties encountered in the execution of this broad, general plan can scarcely be appreciated even by those who are somewhat familiar with the situation. The contracts for the removal of 5,000,000 cu. yd. of material have already been completed, while contracts for the removal of an additional 11,000,000 cu. yd. have been awarded and are to be completed in the next two years. A total of 11,000,000 cu. yd. additional is to be moved under plans which are in such shape that contracts for the work will be awarded as soon as legal details can be adjusted. A grand total of over 27,000,000 cu. yd. of excavation is thus required to execute that portion of the general plan which will certainly be followed to completion at once.

In addition to the vast amount of work involved in moving such enormous quantities of material from areas largely within, or adjacent to, the business district of a city is the necessity for the complete reconstruction of the improvements in large districts. Where the cutting has been heavy, the existing buildings have usually been razed or moved away in advance of the excavation. In other places where the streets have simply been widened in excavation through well-improved sections, the buildings on both sides of the street have been moved back or cut back the required amount. Existing structures in the areas to be raised by fills have either been disposed of, raised up to the new levels on shoring, or protected by retaining walls. The property damages thus involved have been enormous, but almost without exception the land has been so greatly benefited by the improvements as to offset any such damages.

Reclamation of Tide Flats.—The details of the various re-grades that have been completed or that are under way, and the methods of handling the excavation and fill in these districts will be considered by starting at the south end of the city and extending through to the north, although the work has not been handled chronologically in this manner. Practically the first work done in reclaiming the tide flats was carried on by a private company which proposed to build a canal from Elliott Bay through Beacon Hill to Lake Washington. This canal was to connect with two wide, deep-water basins at the south end of the Bay. These basins were to be formed by dredging the two channels by which the Duwamish River enters the Bay, the excavated material being used to raise the level of the submerged land between the two basins to 18 in. above maximum high tide. The excess of the material required to thus reclaim this area was to be utilized in raising the grade of adjacent land to the same level. These two waterways have largely been completed as originally proposed, approximately 7,000,000 cu. yd. of material having been deposited on the adjacent low land. The dredging is still in progress, but the canal through the hill was abandoned after a considerable amount of earth had been removed, since this canal would require a cut of upwards of 350 ft. that would simply isolate the districts to the south of it from the balance of the city. While this dredging has reclaimed a large area of land to a level just above high tide, this reclamation work is small as compared with that which has been done and is to be undertaken with material from the hills in conjunction with the general plans for re-grading the city.

The first removal of material from Beacon Hill, to be used in raising the level of the tide flats was done by the Lewis Construction Co. to provide 250,000 cu. yd. of filling for the relocation of the tracks of the Northern Pacific R. R. This railroad formerly entered the city along the base of Beacon Hill, and extended to a terminal on the water-front along the central business district. As a part of the general plans for the re-grading this railroad has been moved well out on the tide flats and a union passenger station built at the north end of the latter. The Great Northern R. R. formerly entered the city from the north and extended along the water-front of the business district to a terminal south of the original terminal of the Northern Pacific R. R. The former railroad now enters the same station as the latter through a tunnel under the business section of the city, and is constructing terminals adjacent to those of the Northern Pacific R. R. With the exception of a few switch tracks, the traffic of both these railroads has thus been removed from the water-front.

The Chicago, Milwaukee & St. Paul R. R., and the extension of the Harriman Lines, both of which railroads are being built into Seattle, will occupy terminals adjacent to those of the two railroads already operating into the city. All of the railroad terminals and switching yards, except the few switch tracks along the water-front of the business district, will thus be concentrated in the reclaimed tide flats. The latter are being graded accordingly, although the four main north and south streets extending to the business district, and the principal cross-town streets will be raised to the heights necessary to obtain proper grades and to secure overhead crossings of the railroad yards. In order to accomplish this result, the portions of the tide flats to be utilized for railroad purposes have been, or are being, raised 6 to 15 ft. above high-tide level. The streets have been established at new grades 22 ft. above the grades of the railroad fills, and will be carried at the new grades on fills or trestles.

The material obtained from Beacon Hill by the Lewis Construction Co., to make the first part of the tide-flat fill, was taken out of a butte that rose to a height of 50 to 100 ft. above the general level of the top of the hill, near the point where Dearborn St. will be cut through the latter. The main part of the hill in the vicinity of the point occupied by this butte rises quite abruptly from the edge of the tide flats to a height of 175 to 335 ft. above high-tide level, and then drops away on even steeper slopes into Rainier Valley, the top of the hill being very narrow. The existing grades on the Dearborn St. are as great as 25 per cent. on the Sound side of the hill, while the street has never been opened on the opposite side, owing to abruptness of the hill on that side. According to the plans under which this street will be driven through the hill, cuts of from 20 to 135 ft. will be made to reduce the existing grades to the established maximum of less than 2 per cent. On the other hand, areas adjacent to this street will not all be cut down proportionately, as the general plan for grade reduction provides for changes in the north and south streets which require some of the latter to be maintained at higher levels. Except for the work done by the Lewis Construction Co., the reduction of this immediate portion of the hill has not been placed under contract as yet, although the preliminary legal processes necessary have been completed.

The material that was first taken out of the hill to provide the 250,000 cu. yd. of filling for the Northern Pacific R. R. is typical of that encountered in the remainder of this hill, and, in fact, in most of the hills in which work has been done, since all of these hills were formed by the same glacial movements. On account of this origin of the materials the latter are in definite lenses that are distributed with little or no regularity. In general, however, the top soil is a sandy loam and sandy yellow clay of varying depths, that contains occasional pockets of gravel and boulders. Under this top soil is a deep stratum of firm blue clay, through which are distributed numerous pockets of boulders and deposits of cemented conglomerate. Much of this blue clay, and the pockets of boulders and conglomerate contained in it require light blasting before they can be removed.

Notwithstanding the apparently adverse character of the bulk of the materials to be handled, the first 250,000-yd. cut was made with hydraulic giants, and the loosened materials carried in flumes to the position they were to occupy in the flats, which was upward of three-quarters of a mile from the point where the cut was made. A large part of the excavation made since then in connection with the re-grading has been handled in the same manner, and most of that to be moved under uncompleted contracts will also be hydrauliced from place and delivered in flumes to the final position it is to occupy.

The plant installed by the Lewis Construction Co. to handle this first work was not as complete as has been developed by that company and allied interests on other contracts undertaken later. Water was first obtained under a head of about 200 ft. from the surplus of a reservoir of the municipal water-works system on the hill above the cut. This water was delivered to the cut by a 14-in. wood-stave pipe line, from which three branches were taken to supply as many giants at the face of the excavation. The loosened materials were carried by races from the face of the excavation to the flume leading to the fill in the tide flats. The top sandy soil was first stripped from the site of the cut, as it was not expected to furnish as great a quantity of material to the railroad company as was afterwards removed. As a consequence, the hard underlying blue clay had to be loosened by the giants and carried to the flumes without the assistance of the lubricating effect that could be obtained with the sandy material. In spite of this condition the work was successfully accomplished by the hydraulic mining and sluicing method.

(To be continued.)

Sand Filling by Pumping was used in grading the Rosedale, Kan., yard of the Missouri, Kansas & Texas Terminal Co., near Kansas City. The site originally was on an average about 12 ft. below the present grade of the yard. The sand was pumped about a mile through a 12-in. wrought iron spiral pipe of No. 14 B. W. gauge from the Kaw River. The line was carried under a ridge through a tunnel about 80 ft. above low water, and 48 ft. above the grade of the yard. The river end of the pipe was carried on pontoons from the bank to a barge, where it was connected with a centrifugal pump driven by a 150-h.-p. steam engine. A 250-h.-p. gas engine and another centrifugal pump were placed on the river bank. A dike was built along Turkey Creek, which runs through the yard site, to retain the sand discharged by the pipe line, the water finding its way back to the Kaw River by way of the creek. The pump on the barge in this original installation was able to deliver water and sand to the pump on shore faster than the latter could send it over the hill, and after two months of operation under these unsatisfactory conditions the plant was taken over by the terminal company and operated by Mr. F. W. Fratt, the chief engineer. He installed a centrifugal pump and a 175-h.-p. gas engine on the other side of the hill at about the grade of the yard, and improved the other pumps. The work thereafter went on without interruption. Approximately 480,000 cu. yd. of sand were deposited. When the work was half finished it was necessary to renew the pipe line throughout, and the second line was practically worthless at the close of the work. The minimum amount pumped per day of 24 hours, according to "The Railroad Gazette," was 800 cu. yd. and the maximum 1,500 cu. yd. The greatest distance pumped was a little over 6,000 ft. The mixture of sand and water contained about 10 per cent. sand.

Heating Systems for Mills.

The design and operation of heating systems for manufacturing buildings are continuously receiving more thorough attention as the value of comfortable quarters for operatives is better appreciated. Three distinct types of heating systems for buildings of this character are in common use: Direct radiation, the indirect or hot-blast system, and forced hot-water circulation. These three methods of heating as applied to mill buildings were fully discussed in a paper presented before the National Association of Cotton Manufacturers by Mr. A. G. Hosmer, from which paper the following notes have been prepared.

In the use of direct radiation operated with exhaust steam from non-condensing engines, by placing a light back pressure on the engines to force the exhaust through the pipes at the proper velocity, it should be borne in mind that the adding of one pound of back pressure to an engine cannot be made up by adding one pound to the initial pressure. If the areas of the pipes are ample and they are not too long or complicated, this method works well, but as it is often not the condition, the steam is condensed before it reaches the end of its journey, rendering it almost useless as a source of heat for a considerable part of the way. In this case the back pressure must either be raised or direct steam turned in to accomplish the desired end.

Adding back pressure to an engine, especially if it is large and well loaded, should be avoided if possible. From the foregoing it would seem that the entire heat from exhaust steam cannot usually be utilized without running more or less back pressure on the engines, and therefore cannot be forced or hurried to any extent unless disagreeable conditions are brought about in the engine room. In some instances the circulation of the exhaust is assisted by applying a vacuum at the discharge end of the system, thus doing away with the objectionable back pressure on the engines. This is a decided advantage if the engines are large, but it necessitates the complication of piping, with the cost and running expense of some more or less elaborate system for the maintenance of the vacuum. As a rule, the method of heating by exhaust steam leaves a great deal to be desired and is not advisable unless it is necessary to use non-condensing engines.

Taking low pressure steam from the receiver of a compound engine is a common practice in some mills. If the quantity of steam taken is fairly constant and the engine is designed with that object in view, the results are quite satisfactory, although this idea is usually more popular with the designing than the operating engineer.

It is well to remember when designing any supply of heat for the purpose of warming buildings of a manufacturing plant that exhaust or receiver steam is available only during running hours, and that the heating system's highest duty is usually required when the engines are shut down; consequently, it is more important to have an efficient service during non-running hours than at times when machinery friction and other causes contribute to the warmth of the work rooms.

With a direct system designed for the use of live or boiler steam alone, which is reduced in pressure and sent to the heating pipes, remaining there until condensed and finally discharged through a trap to the atmosphere or to a tank to be fed back to the boilers, nearly the same pressure is, with the trap working properly, kept on the entire length of pipes and all the water is automatically removed. This renders every foot of pipe equally efficient, with the heat nearly uniform, due to the pressure carried. In a building or series of buildings closely grouped and with it possible to have the drips carried to some point somewhat lower than any of the heating pipes and not too far from the boilers, the condensation ought never to be cooler than 200° Fahr., and can be pumped or trapped to them without much loss of heat. If piping is large and well installed with separate traps for each considerable unit of circulation this will be found to be one of the most economical and satisfactory methods of heating. It can be forced or moderated within reasonable limits by raising or lowering the pressure at the reducing valve and, with everything right, will give return for practically all the heat expended.

The benefit of returning the condensation to the boilers is quite often not realized in many plants fitted for so doing, for the reason that a pump designed and used for handling very hot water is one of the most difficult appliances to keep in repair with which the mechanic has to deal. Consequently, the general tendency is to neglect this important feature, and as the heating can be done without it, that is, by running the water to waste, the pump is allowed to stand idle for a great part of the time. This should not be permitted, as the expense of keeping the pump in first-class order is a small item, compared with the loss of the heated condensation.

In buildings equipped with either the direct or hot-water systems where no wall space is required for storage or other purposes the heating pipes can be placed around the sides below the windows; as warm air naturally rises, this location insures good heat distribution and comfort for the operatives. The prevailing custom at the present time is, however, to arrange the pipes on the ceilings, where they will not be injured by passing trucks or obscured by material stored in front of them. With the overhead location the coils are not as liable to become repositories for brooms, clothing, waste or other refuse which might ignite and cause serious damage by fire.

Pipes of a given area arranged as in the fan system, where cool air passes through them very rapidly, are many times more efficient than a radiating surface of the same area exposed in still air. The fresh air for use in this system is usually supplied from out of doors, and in heating weather is always cool enough to absorb heat from almost any source of even moderate temperature, so that warm water from condensers circulated through pipes, furnace gases passing through large flues on their way from economizers to chimney (when artificial draft is employed), together with live and exhaust steam, can be used successfully. Direct steam-heating coils are usually located so that condensation can be returned to the boilers. Heaters using exhaust steam should be so arranged that the cool air passes through or over them in the opposite direction to the current of steam and enters at the cool or discharge end. It is customary to arrange the fan to draw the air through the coils and force it to the various rooms.

It is important that the openings from air trunks into the rooms should be of moderate size and well distributed, and that the size and capacity of the fan and heaters should be such that the required volume of supply can be furnished at a moderate velocity without causing too much of a current. In many cases this system has not given satisfaction from the failure to give attention to the above points.

Rooms in exposed locations or on the north side of a building always require more heat than those more fortunately situated. These can be accommodated in any indirect system, without making any change in the heating plant proper, by placing auxiliary coils in the main ducts leading to the points where extra service is required. It is also often possible to obtain very economical results with this system by using the air more than once, or taking warm air from one department, where there may be a surplus of heat from the nature of the work, to a cooler department. This necessitates a return duct or by-pass back to the suction side of fan and is not feasible unless the rooms and heating plant are quite near together.

The advantages of this system are many, and for some kinds of manufacturing, particularly where a moderate heat and plenty of fresh air is needed, is perhaps the best in use. It is quite simple, and the parts requiring care are compact, with no heating pipes located where freezing is possible, or leakage can do much damage. Results can be obtained very quickly, and in many cases the warm air need not be turned into the rooms until within a few minutes before starting time. In some parts of textile manufacture this constant changing over of the air is not desirable, having a tendency to make the rooms too dry, and unless the incoming air is moistened by some means before entering, conditions are too much dependent on the weather. In rooms filled with revolving shafting and pulleys the current set up by the fan should not be as strong as in those without machinery.

In order to obtain satisfactory results with the hot-water or forced-circulating system, the speed of the water through the circulating pipes must be high to prevent any too sluggish movement in the shunts or isolated coils that offer a little more frictional resistance than the direct lines. The temperature should also not be allowed to fall very much during its passage through the entire system to secure uniform efficiency throughout. In ordinarily cool weather it should be sent out as warm as 200° Fahr. and returned at not less than 150° Fahr.

In some plants this system has been installed with a view of utilizing the heat of the exhaust steam from condensing engines on its way to the condenser, by placing a heater between and running the engines with a vacuum more or less reduced. If, as has been mentioned, the temperature of the outgoing water should be about 200° Fahr. and that entering the heater 150° Fahr., it is evident that to enable it to absorb any heat from the exhaust, the vacuum would have to be adjusted to make the temperature of said exhaust somewhat above 150°, or at least 160° Fahr.; this corresponds to a vacuum of about 20 in., or 5 lb., absolute pressure. At a temperature of 180° Fahr. we have only 12 in. and at 200° Fahr., 6 in., or a little less than one-fourth of the usual efficiency of the condenser. The choice is offered then to run either a low vacuum and sacrifice a portion of the benefit derived from the condenser, or to add live steam in a secondary heater to make up for what the low-pressure steam cannot do.

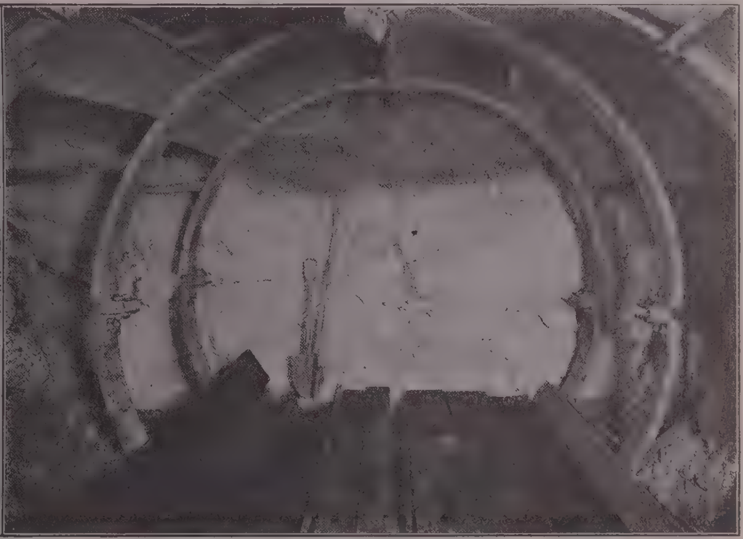
For efficient results with this method of heating the water while passing through the exhaust chamber, the size of engines and capacity or requirements of the circulating system should be so proportioned that the passing water will absorb the entire amount of available heat in the exhaust steam. To illustrate, suppose the engines are running with a vacuum of 12 in. to give the exhaust a temperature of about 180° Fahr.; our circulating water enters the heater at 150° Fahr., thus we have 30° Fahr. available. If the quantity of water exposed in the heater is sufficient to absorb all the heat passing in the exhaust (that is, heat above 150° Fahr.), all is well, but as the temperature of this heating medium is governed wholly by the condition of the vacuum, regardless of the quantity of exhaust going by, any excess will pass through without giving up its available heat, and the impaired vacuum will have to be made up by steam from the boilers, for a part of which there will be no return. In other words, enough extra heat in form of boiler steam will have to be added to raise the mean effective pressure to the point it would be with regular conditions in condenser, and as a return only what heat has been absorbed by the circulating water will be received.

Every 2.04 in. taken from the vacuum decreases the mean effective pressure one pound. It will be remembered that back pressure or vacuum, as the condition on the discharge side of an engine may be called, applies to the entire length of stroke the same as mean effective pressure. It is therefore evident that the raising or lowering of this pressure, even a few pounds, on a large engine cylinder means quite a serious difference in the important work done by the condenser and the power output of the engine.

If the quantity of exhaust steam is insufficient at times, care must be taken to avoid lowering the vacuum too much, as it will spoil regulation, and complicate things generally, especially with compound engines. The line between waste and economy in this proposition is so finely drawn that to use the minimum temperature of the exhaust with also the minimum amount of direct steam, and realize the best conditions, the adjustments should be watched very closely.

In installations where the engines and condenser systems are not considered and direct steam used entirely, the heaters are usually placed in the boiler house enough above the water line of boilers to insure a gravity return for the condensation. Provision must, of course, be made for operating the circulating pump at night and during holidays and Sundays. In nearly all equipments of this kind a supplementary heater or section of one of the heaters is used for the exhaust from the pump engine or turbine.

Lined Portion in a Section in Rock.


Heading in Part Rock and Part Clay.

As has been spoken of before, the most severe duty on the system comes when the plant is shut down, particularly early mornings. At such times the water must be used at the maximum temperature, and as the exhaust from engine is not over 210° Fahr., unless back pressure is made use of, the steam will pass by the water coils, transferring little or no heat to them. In places where condensing water is available it is sometimes better to install a small condenser for the pump engine and to do away with the inefficient exhaust heater.

The circulating system is sometimes connected with the economizers to use the waste heat passing to chimney during non-running hours. While the theory of this is excellent, in practice it is hardly ever desirable, for the reason that the economizers during working hours are handling water quite hot and at a high pressure, and if cooler water at a much lower pressure is introduced it contracts the joints and produces a change in conditions which usually develops more or less serious leaks and perhaps the loss of a gasket when the high pressure is again admitted. The repairing of economizer joints is not a pleasant task, to say nothing of the trouble and expense of having the machine out of commission when needed.

This system cannot be hurried to any extent, and it is consequently advisable to avoid letting a building cool down very much during cold weather by running the circulation continually. In this respect a direct-heating system using steam has a material advantage, as it is seldom needed until a few hours before starting time and rarely through the entire day.

In case of accidents to the machinery driving the pump a bad feature presents itself, as it is necessary to use steam in the circulating pipes instead of water. This is almost sure to cause trouble if the pockets or drops in the lines are not properly drained, as the entrapped condensation will cause hammering with innumerable leaks and frequently split some large fitting. Particular attention should be always given to installations of this kind to arrange the pipes with the same pitch and draining facilities that would be required if high-pressure steam was used.

The excessive number and size of pipes required in this system is quite a detriment in plants where space on walls or ceilings is limited and lighting capacity not the best. For a plant consisting of many buildings scattered, and at some distance from the boilers, the hot-water system is admirably adapted. If the heaters are large and well installed, where little or no heat can be lost by radiation, with direct steam condensation returned to boilers at little or no expense, and with a pump operated economically, nearly all the heat taken from the boilers can be made good use of and a service provided unattainable by any other means.

The first cost of the different systems varies greatly and depends somewhat upon local conditions, but usually the steam equipment is much cheaper than either the blower or hot-water system. It appears quite evident that no one system possesses all the advantages or can fulfill the requirements in every case, and that where one would be of excellent service another would fall far short of giving satisfaction. In any plant of considerable size and devoted to many different processes it usually occurs that in some departments or buildings one particular type is better adapted and will give much better results than any other; it seems sensible, therefore, in considering heating facilities for such a plant to abandon the idea of employing one system alone.

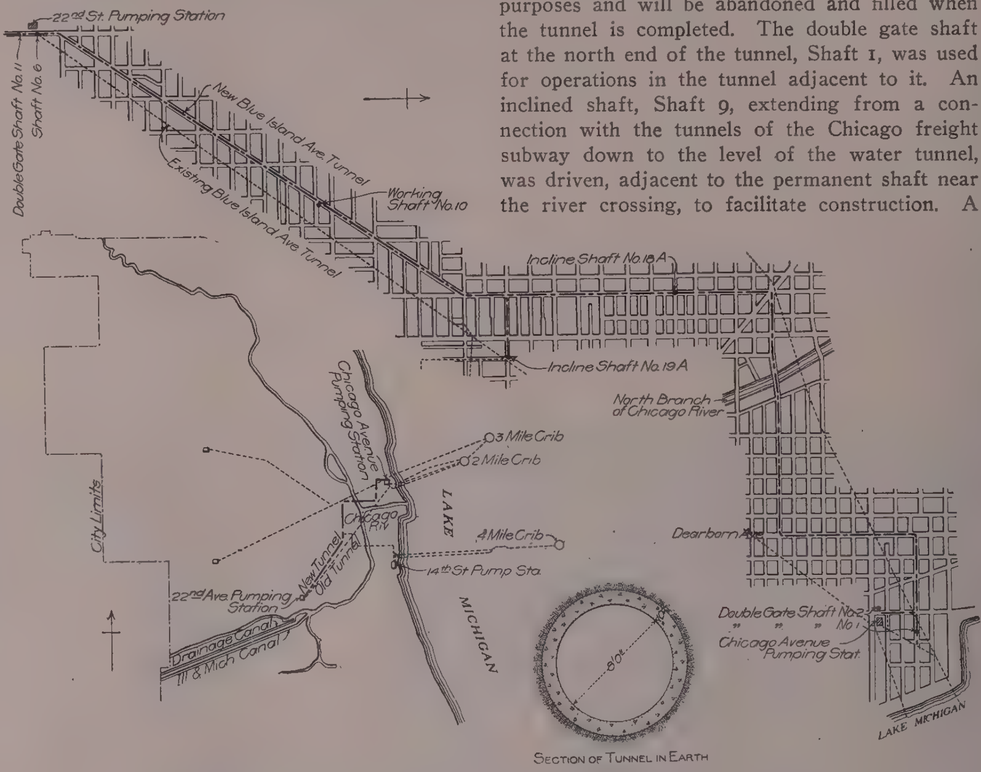
A Traveling Car-Inverting Dumper has been built at the McKeesport plant of the National Tube Co. It weighs about 325 tons and will handle ore cars up to 50 ft. long, 11½ ft. wide and 12 ft. high, as well as short gondolas and steel hopper cars. The cars are run on to it by inclined approaches attached to the dumper.

The New Blue Island Avenue Water Tunnel, Chicago.

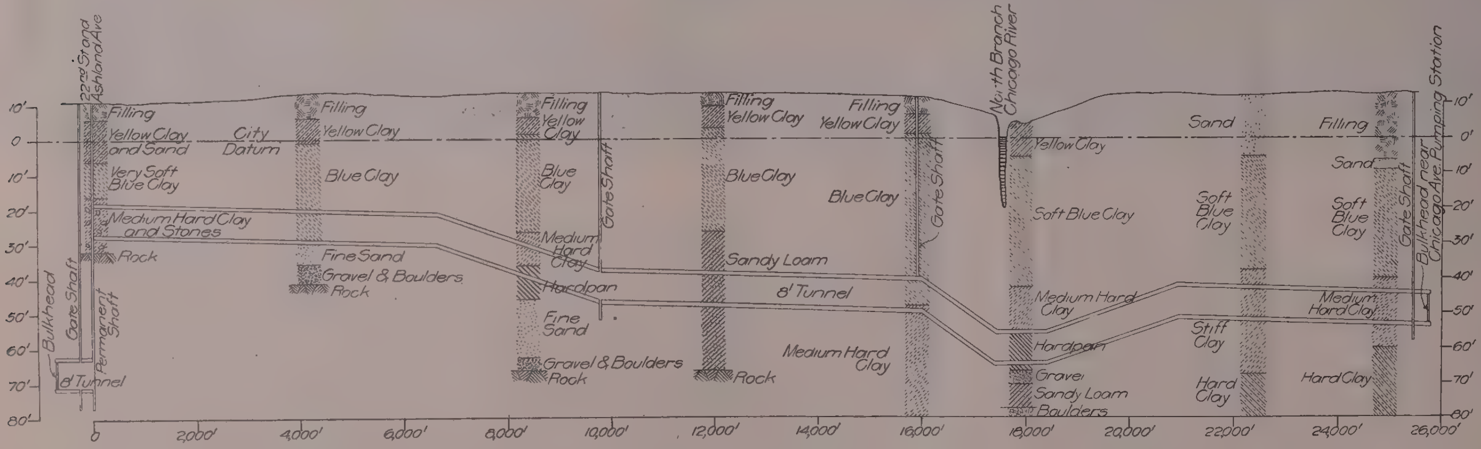
An 8-ft. circular tunnel, having a total length of approximately 28,000 ft., is being driven in Chicago to form a part of the system of tunnels connecting the intake cribs in Lake Michigan with the pumping stations from which the distribution mains of the municipal water-works are supplied under direct pressure. This tunnel starts near a pumping station at Chicago Ave., close to the shore of Lake Michigan and about a mile north of the central business district, and extends west and south from this point in the rear of that district to a pumping station at Twenty-second St. and Ashland Ave. The latter station, with a capacity of 60,000,000 gal. per day, supplies a great manufacturing district in that section of the city.

The Chicago Ave. pumping station, with a present capacity of 100,000,000 gal. a day, is connected by a 5-ft. and two 7-ft. tunnels under the bottom of the lake with a crib 2 miles off-shore. This station can also be supplied from a connection with a 10-ft. tunnel that leads from a second crib, 3 miles off-shore from Chicago Ave., to two pumping stations on the west side of the city. The Twenty-second St. station at present draws water from an existing 7-ft. Blue Island Ave. tunnel that extends to it from a connection with the 5-ft. and two 7-ft. tunnels from the 2-mile crib. A 7-ft. connection between this existing Blue Island Ave. tunnel and a 7-ft. tunnel from a third crib off-shore at a point about 3 miles south of the two cribs out from Chicago Ave. is also made on the west side of the business district, 2 miles northeast from the Twenty-second St. station. The tunnel from the 4-mile crib primarily supplies an 85,000,000-gal. pumping station at Fourteenth St. close to the shore of the lake and a mile south of the central business district. These various cross connections thus permit the three pumping stations mentioned to be supplied in various ways by means of the different tunnels extending to the intake cribs in the lake.

The new 8-ft. Blue Island Ave. tunnel is being driven to replace the existing 7-ft. one designated by the same name, and the latter tunnel will be abandoned when the new one is completed. The old 7-ft. tunnel extends diagonally across the portion of the city under which it was built, without any reference to the arrangement of the streets on the surface. As the tunnel is at a depth of only 60 to 70 ft. in the blue clay and other materials which overlie bed-rock, it is continually liable to damage from piles driven to secure foundations for structures on the private property under which it crosses. On this account, the new 8-ft. tunnel is being built under the city streets to replace it, and also to secure additional capacity to meet increased demands for water.



General and Detail Locations of Blue Island Avenue Tunnel.



Profile of New Blue Island Avenue Tunnel, Showing Character of Materials Encountered.

The new tunnel will have the same connections with the other tunnels that have been provided for the existing one. Plans have also been made to drive a lake tunnel from the two-mile crib offshore from the Chicago Ave. station, to the three-mile crib, in order that the former crib may be abandoned. The new 8-ft. Blue Island Ave. tunnel will then be extended from a bulkhead near that station, at which it terminates at present, to a connection with this new lake tunnel. It is also further proposed to move the pumping station at Twenty-second St. south to Thirty-first St., and to make the capacity of the new station 100,000,000 gal. per day. This change will involve the extension of the new 8-ft. Blue Island Ave. tunnel, which is of sufficient capacity to provide for the increase in the output of the pumping station.

The new tunnel has a uniform cross-section 8 ft. in diameter and is lined with concrete, having a minimum thickness of 10 in. in earth. The profile of the tunnel is shown in an accompanying illustration, from which it may be seen that the ground surface in the area crossed is 10 to 12 ft. above Chicago city datum, which is taken as a basis of elevation and is practically at the mean stage of the Chicago River. The tunnel invert at the bulkhead near the Chicago Ave. pumping station, at which bulkhead that end of the tunnel at present terminates, is at a depth of 52.5 ft. below datum. From this bulkhead the tunnel is on a 0.41 per cent. ascending grade for about 4,800 ft., and then drops away on a 0.576 per cent. grade, as an approach to the crossing under the north branch of the Chicago River, about 1.5 miles from the bulkhead. This crossing is made with the tunnel invert 64 ft. below datum, or 44 ft. under the bottom of the river and 75 ft. below the surface. Beyond it the tunnel rises for 1,200 ft. on a 1.07 per cent. grade, and then extends to the Twenty-second St. pumping station at increasingly less depth below the surface.

The materials through which the tunnel is being driven are typical of those that have been encountered in driving many of the previous water tunnels in Chicago, and in practically all the tunnels of the Chicago freight subway. North of the Chicago River bed-rock is at a depth of 100 ft. or more, but south of the river crossing the top of the rock is on a fairly uniform flat slope rising toward the surface of the ground, until in the vicinity of the Twenty-second St. station it is at a depth of only 30 to 40 ft. The bed-rock is overlaid in most places by a stratum of gravel, boulders and hardpan, containing occasional pockets of quicksand. Over this stratum is generally found a deep, heavy bed of clay, which changes gradually, at varying elevations below datum, from hardpan at the bottom to soft blue clay, and then near datum to a top stratum of yellow clay, on which various kinds of material have been placed as filling to raise the grade of the city. Although these are the general characteristics of the deep bed of clay, the latter contains numerous fairly well-defined deposits of sand, sandy loam, gravel and soft clay.

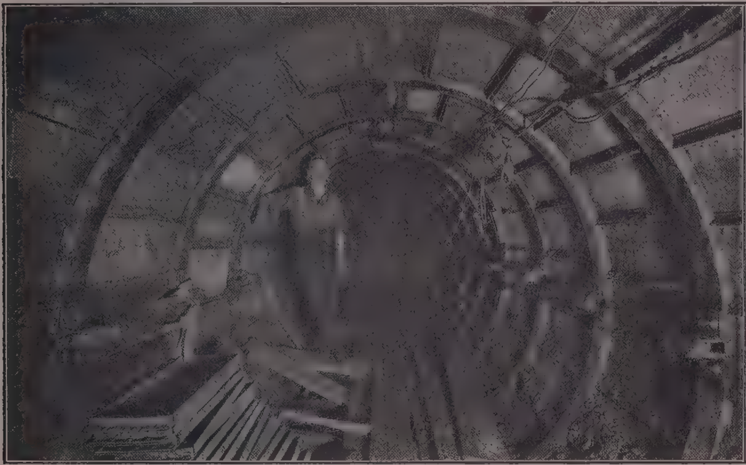
From the end of the tunnel at the lake, for nearly 2.5 miles, the excavation has been in material varying from hardpan to stiff blue clay, with few exceptions. At the end of this section borings showed the bed-rock to be overlaid directly in various places by sandy soil and fine dry sand, but the ascending grade of the tunnel in this vicinity permitted the excavation to be made in good clay, barring a few short stretches where sandy soil or soft clay was encountered. For between 400 and 500 ft. from the present south end of the tunnel the excavation was made in solid rock; and in the next 800 ft. north of this rock section the grade of the tunnel brought the lower part of the cross-section of the latter in rock and the upper part in stiff blue clay.

The tunnel is to have seven permanent shafts for controlling gates and other purposes. One of these shafts containing two gates is adjacent to the bulkhead at the north end of the tunnel, and a second, also containing two gates, is at the end of a branch extending from the tunnel to the Chicago Ave. pumping station. The next shaft in order is one for pumping out, that contains no gate and is close to the crossing under the river. About 1.25 miles beyond this crossing a 1,252-ft. branch connects the Blue Island Ave. tunnel with the 7-ft. Polk St. tunnel and a double gate shaft is placed close to the end of this connection. A double gate shaft is also placed on the main tunnel just north of the junction of the branch connection with it. The next permanent shaft is one without gates at the Twenty-second St. pumping station, and the last one, containing two gates, is just beyond that station.

The tunnel has been driven simultaneously from six shafts, two of which are permanent, while the other four were built strictly for working purposes and will be abandoned and filled when the tunnel is completed. The double gate shaft at the north end of the tunnel, Shaft 1, was used for operations in the tunnel adjacent to it. An inclined shaft, Shaft 9, extending from a connection with the tunnels of the Chicago freight subway down to the level of the water tunnel, was driven, adjacent to the permanent shaft near the river crossing, to facilitate construction. A similar inclined shaft, Shaft 18-A, was built about half way between the river crossing and the junction of the tunnel with the branch connection to the Polk St. tunnel. A third inclined shaft, Shaft 19-A, was built at the end of this branch connection. The next working shaft, Shaft 10, extended to the ground surface and was located south of the junction of the Polk St. branch connection with the main tunnel, about one-third of the distance to the Twenty-second St. pumping station from that junction. The permanent shaft at that pumping station, Shaft No. 6, was also utilized for working purposes. With the exception of Shafts 1 and 6 at the ends of the tunnel, and in the case of Shaft 19-A, until the branch connection driven from the latter shaft had reached the main tunnel, two headings were driven continuously from each of the working shafts. The distance each of the ten headings, in which tunnel operations were prosecuted, had to be driven was thus approximately the same, averaging a total of about half a mile in each case.

The arrangement of the three inclined shafts connecting the tunnels of the Chicago subway with the headings of the water tunnel, and the operation of these shafts were so similar that a description of one of them will apply in general to the other two, taking as an example Shaft 9, the one adjacent to the crossing under the river. At this point a three-way intersection of the tunnels of the subway occurs, and operations have been in progress in several headings in which these subway tunnels are being extended simultaneously with the driving of the water tunnel. The latter is 64 ft. below Chicago datum at this point, while the adjacent subway tunnels are only 44 ft. below datum, and the three-way intersection is about 20 ft. horizontally from the water tunnel.

As the subway tunnels and the water tunnel are being driven under contract by the forces of the same organization, George W. Jackson, Inc., of Chicago, the operations in both have been handled in conjunction. A 7.5-ft. circular elevator shaft was sunk from the surface down to the level of the subway tunnels, about 150 ft. from the three-way intersection in the latter. Since operations in the subway and the water tunnel are generally carried on under 8 to 12-lb. air pressure, an air lock was built in the subway tunnel between the foot of the elevator shaft and the subway-tunnel intersection. In the rear of this lock a 5.5-ft. circular shaft was dug on a steep grade from the subway tunnel down to the water tunnel. This incline was then used in removing materials and in delivering supplies to the water tunnel. Headings were started in both directions from the foot of the incline, and at the time these notes were prepared had each advanced upwards of 1,500 ft., so they were approaching a junction with the headings from adjacent shafts. Stiff blue clay, with occasional soft pockets and some occurrences of harder material, has been encountered in both of these headings. As a consequence, exactly similar methods have been used in both of them, and these methods are, in fact, practically the same that have been employed in all the other headings, except in the short section of rock.


Steel Ribs and Lagging in Place for Concrete Forms.

Typical Character of Clay Encountered in Headings.

The work is prosecuted continuously by three 8-hr. shifts, with 8 to 10 men in a shift at each heading, depending on conditions. Most of the clay is of such nature that it can be cut out in long, thin slabs with a draw-knife similar to the one used by carpenters. The materials too hard to be handled in this manner are mined by means of adzes with long handles. The bore of the tunnel can, therefore, be cut to almost exact dimensions. Under the air pressure used the shape of the bore is also readily maintained, without any timbering or bracing of any kind, until the concrete lining is in place and has set.

Four or five miners, two shovelers and a car pusher are worked in each heading to a shift. The excavated materials are loaded into ½-yd. cars, with bodies having loose sides and ends. These cars operate on an 18-in. gauge track laid in the bottom of the tunnel, and are hauled to the foot of the inclined shaft in trains of four to six by a mule. They are then pulled up this shaft by a cable on a motor-driven hoist in a recess in one side of the subway tunnel at the head of the incline. After the cars reach the subway tunnel they are pushed through the air lock into a chamber in which the cross-section of the subway tunnel is increased for a short distance from the standard width and height of 6.5 and 7.5 ft., respectively, to 10 ft. in width and height.

A regular subway car track is laid along one side of this enlarged section, and connects with the tracks in the remainder of the subway system. A platform level with the tops of the 3-yd. material cars operated in the subway is placed along the opposite side of the enlarged section from this track so the small tunnel cars may be pulled up an incline leading to this platform and their contents dumped into the subway cars. The latter are hauled through the subway to a connection extending out on a park site, which is being made by reclaiming a large area of land along the lake front of the business section of the city, and the material is used for filling on this land. In this manner none of the excavated materials from this shaft and from Shafts 18-A and 19-A are ever brought to the surface, with the result that they are removed with remarkable rapidity and the city streets are entirely free from the great litter that would be dropped from the large number of wagons which would otherwise have to be used. The materials resulting from the mining operations in Shaft 10 are necessarily hoisted to the surface, as no line of subway tunnels is adjacent to that shaft. They are, however, hauled in wagons on the surface only a short distance from that shaft to a chute leading down to one of the subway tunnels. The spoil from Shafts 1 and 6, at the ends of the water tunnel, are utilized in raising the grade of adjacent low areas, but as only one heading has been driven from each of these shafts, by far the bulk of the spoil from the tunnels has gone to the lake-front fill through the subway.

When work is in progress at the headings under air pressure, mining is normally carried on by two consecutive shifts followed by one shift working on the concrete lining. With this sequence of operations 18 ft. of finished 8-ft. tunnel is generally built every 24 hr. in each heading. In places where specially stiff clay or hardpan is encountered mining can occasionally be continued for 21 to 24 ft. in advance of the completion of the tunnel lining, although under such conditions the invert of the lining is built as the mining is finished. On the other hand, when soft material is encountered, or when air pressure is not used, each 8-hr. shift mines 6 ft. of tunnel and places the lining of the excavation opened during that shift. The progress in headings driven from Shaft 9 is in no way exceptional, as 18 ft. of advance per 24 hr. is the normal schedule for each heading, and the contractor drove and lined over 20,000 ft. of the water tunnel from August, 1907, to April 15.

A concrete-mixing plant is installed on vacant property adjacent to the mouth of the elevator shaft leading down to the subway tunnels at Shaft 9. Two steam-driven 12 x 18 x 18-in. Laidlaw-Dunn-Gordon air compressors are also installed in duplicate in connection with this plant to maintain the air pressure in all the headings in the rear of the lock in the subway tunnel. The concrete materials are delivered to mixing plants in wagons and the concrete is made in a continuous mixer of the pug-mill type. The mixer discharges in ½-yd. dump cars of the same pattern used to handle spoil from the headings in the water tunnel to the subway tunnel. The cars of concrete are lowered into the subway in the elevator shaft and thence through the inclined shaft into the water tunnel, where they are hauled to the point at which work on lining is in progress.

Steel ribs and lagging of a special type designed and patented by Mr. George W. Jackson, are used as forms for the concrete lining of the tunnel. These lagging ribs are built of 5-in., 9-lb. channels bent to the radius of the circle required to bring the lagging to the proper curve, with flanges of the channels out. Each rib is made up of four sections, each section being a 90-deg. arc of a circle. The joints between the ends of the four sections of each rib are arranged to come at the ends of the vertical and horizontal diameters of the circle. These joints are made by means of bolts in angles riveted to the channels. Those at the top and bottom of the rib are built at an angle to the axis of the rib, while those along the sides provide space for wedging blocks in them. The lagging used with these ribs consists of 3-ft. lengths of ¼-in steel plates, 12-in. wide. These plates have a light steel angle riveted along both sides and both ends of them, so as to form a rim entirely around the plate that is flush with the edges of the latter. The angles on the sides of these plates are notched to fit over the flanges of the channels of the ribs, which can thus be spaced accurately by placing a few of the lagging sections. At the same time, the joints between the edges of the adjacent sections of lagging can be made quite smooth and tight enough to hold concrete.

As fast as the mining is carried ahead of the portion of the finished tunnel lining, the concrete in the lowest part of the invert is generally placed to provide for the erection of the steel lagging ribs, although the latter can be blocked up readily. When the ribs are placed, the lagging for the lower part of the circle is set and the invert lining finished up part way on each side. The spoil-car track and shoveling platform can then be laid on cross-ties formed by a horizontal angle attached to each lagging rib. The concrete lining is completed afterwards.

The concrete is allowed to set for at least 72 hr. before the forms are stripped from it. The removal of the form is very readily accomplished by simply loosening the bolts at the top and side joints of the lagging ribs and by knocking out the wedges in the latter. The forms are then carried ahead and erected again, only a sufficient amount of steel ribs and lagging being provided in each heading to permit the concrete to set the required time. That these forms are practically indestructible under the service given them is indicated by the fact that upward of half a mile of the concrete tunnel lining has been placed with each set of them in use.

The concrete is made in the proportions of 1 part Portland cement, 2 parts sand and 4 parts broken stone, or 1 part cement to 6 parts graded gravel. The inner surface of the concrete lining is comparatively smooth as it comes from the forms, but it is given a coat of cement and sand mortar of sufficient thickness to fill all the irregularities.

The prosecution of operation in the other two inclined shafts connecting with the subway tunnels is practically the same as in the case described in detail. As these other two shafts are located in congested business districts, no space was available on the surface adjacent to them for a concrete-mixing plant. Consequently the latter for Shaft 19-A was located in the basement of a building where materials could be delivered to it from the street through manholes in the sidewalk. Similar conditions also existed at the third inclined shaft connecting with the subway tunnels. In both cases the plant was electrically driven.

In the rock section and in the section where part rock and part clay was encountered, the excavation was carried ahead in practically the same sequence followed in the sections in all clay. The steel ribs and lagging were used to special advantage for the forms of the concrete lining in these sections where the rock was broken irregularly in blasting. Two of the accompanying illustrations show the character of the rock, and in one of these the line of demarcation between the rock and the overlying clay is specially evident.

The various shafts dug from the surface of the ground to level of the tunnel for working purposes, or for permanent gates, were lined with Jackson interlocking sheet piling as they were sunk. At several of these shafts soil conditions were encountered that presented serious hazards, but in all cases the shafts that have been undertaken have been successfully completed by means of the steel sheeting.

The new Blue Island Ave. tunnel was designed and built under the direction of Mr. John Ericson, city engineer, of Chicago. Mr. D. W. Church is principal assistant city engineer; Mr. J. H. Spengler is assistant engineer in charge of the construction, and Mr. W. O. Barber is engineer in local charge of the work. The tunnel is being built by George W. Jackson, Inc., under the supervision of Mr. George W. Jackson, president and chief engineer of that company.

The Proposed Train Ferry between Trelleborg, in Sweden, and Sassnitz, in Germany, a distance of about 65 miles, was endorsed by the Swedish Parliament at a recent session, and the necessary appropriation voted. The total cost, including a section of railroad leading to the port, the improvement of the latter, and the construction of the two ferryboats, will be about $2,430,000.

The Power Plant of the American Biscuit Company, San Francisco.

By Alfred H. Potbury, M. E.

One of the largest factory buildings, as well as one of the largest and most complete factory power plants, constructed in San Francisco since the fire of 1906 is that of the American Biscuit Co., at Broadway, Battery and Vallejo Sts. The building is of reinforced concrete, facing 275 ft. on Battery St. and 127½ ft. on Broadway and Vallejo, covering a half block of city property. With a basement beneath the entire structure and five stories above the sidewalk level, the floor area figures to a little more than four acres. The foundation rests on solid rock which, running below the surface only a few feet, forms the sloping sides of what is known as Telegraph Hill. The rock excavated here for the basement was crushed and utilized in the construction work. The column spans are slightly more than 17 ft. The beams are 12 x 20 in. and are surmounted by a 7-in. floor slab, the whole figured for a live load of 250 lb. per square foot of floor area. The façade of building is an excellent specimen of what can be done with reinforced concrete to produce a pleasing and substantial effect. Mr. Ralph Warner Hart, of San Francisco, was architect and superintendent of construction of the building, while the work of mechanical and electrical installation, of which this article gives a more particular description, was carried on by the writer as the company's engineer, co-operating with the architect wherever the interests of the one became the interests of the other.

The power plant is centrally located in the basement, where a space of about 50 x 75 ft. was set aside for the boiler and engine room. Two 120-h.p. boilers of the Stirling "B-low" type have been installed, with space and connections reserved for a third boiler, as demands for steam throughout the factory will no doubt require the additional equipment at a future time. The steam pressure carried is 150 lb., which passes through the main crossing the front of the boilers to the left of the boilers, a distance of about 30 ft. to the first engine and some 17 ft. further to the second engine. To the right of the boiler the steam is passed through reduction valves and reduced to a lower pressure for use for manufacturing purposes. From two reduction valves it is led by a 3-in. and 4-in. pipe to the floors above ready for distribution at 80 and 90 lb. pressure respectively.

The two engines are Fleming-Harrisburg tandem compound piston valve engines of 120 h.p. each. The engines are noncondensing and deliver their exhaust steam into an 8-in. galvanized spiral-riveted pipe which, passing beneath the floor and returning to the boiler room, delivers its steam first to a Wainwright closed heater (installed to supply a circulating hot water pipe system) and second to a Cochrane feed-water heater for the use of the boilers. The exhaust line leaving the heaters passes through the basement to the back of the building and thence to the roof, a distance of about 200 ft. All of this distance it is exposed to cool air and being properly drained, delivers its water of condensation to a storage tank. The latter is of 10,000 gal. capacity, serving the double purpose of a hot well and an emergency source of water supply in case of failure in city pressure.

The fuel used is oil and a storage tank of 5,000 gal. has been installed with the necessary oil pumps and pipe system for supplying the boiler burners as well as burners used for manufacturing purposes.

The engines are direct connected to two 100-kw. Crocker-Wheeler three-phase sixty-cycle 240-volt generators operating at 277 r.p.m. and arranged for parallel or independent operation. The generators are star-wound with a neutral connection so that the motor voltage is 220 volts on a three-phase three-wire system, while the voltage used for lighting, on a three-phase four-wire system is about 130 volts.

The main switchboard consists of an exciter panel, two generator panels and three feeder panels, the latter controlling the power system, the lighting system, and the four elevator circuits, which are directly connected to the switchboard and independent of other power circuits. An additional switch controlling the machine shop motor is mounted on the elevator panel. The mains for light and power pass to the motors on the floors above in three independent circuits, controlled by the switches above mentioned.

A number of Westinghouse type CCL motors are used throughout the factory and in many cases are directly connected by gears or silent chain drives to the individual machines, while in other cases several machines or a department of work have a single motor furnishing power to short lines of shafting. None of the motors are larger than 15 h.p. and many are as small as 3 and 5 h.p.

One of the most interesting features of the mechanical installation is the construction of the chimney and its use in manufacturing. The chimney is of concrete which, passing from the boiler room through the building, extends above the roof about 12 ft. making its total height about 90 ft. The inside dimension is 4½ ft. square to a height of 30 ft. and 4 ft. 10 in. square the remainder of its height. Within this concrete chimney there is a steel stack 45 in. in diameter which carries the flue gases from the boilers to the top of the building. The space between the concrete wall and the steel stack is utilized as a reservoir of warm air. A 48-in. American blower with a 3-h.p. motor directly connected is installed at the base, draws air from the boiler room (acting therefore as a ventilator), and blows this air into the reservoir already mentioned, where it absorbes additional heat from the hot stack. This air is forced out through suitable galvanized ducts at the fourth and fifth floors where, by a suitable system of inlet and outlet dampers, it is used to heat dry rooms. The temperature of these dry rooms can be easily mantained at 120 deg. Fahr. and a change of air accomplished every 15 minutes at the mere cost of operating the blower. Of course in carrying out this idea care was taken to properly close all leaks in order to insure a good circulation of pure air.

The plant has now been in operation several months and is considered successful by the engineers of San Francisco and represents a private plant ranking among the best of any in the city.

The Concrete Lining on 7,500 lin. ft. of the South Canal of the Uncompahgre project of the U. S. Reclamation Service required 245,085 lin. ft. of ⅜-in. corrugated steel bars weighing about 119,140 lb. Two sections of the canal have been analyzed to show the cost of this reinforcement. Each section has side slopes of ½ to 1, one having a bottom width of 8 ft. and a vertical lined depth of 10.5 ft., and the other having a bottom width of 13 ft., and a vertical lined depth of 8.4 ft. Each of the sections requires about 0.6 cu. yd. of concrete per lineal foot of canal. The steel was hauled an average distance of 4 miles from the railroad siding to the canal. One man was employed placing the steel in the concrete during construction. Labor was paid at the rate of 25 cents per hour, and teams with drivers at the rate of 45 cents per hour. The cost of superintendence of the hauling and placing of the steel has been included with those items and amounts in each case to 15 per cent of the original cost. The official figures show that the cost of the steel was 2.45 cents per pound at the factory, 0.43 cents was paid for freight, 0.07 cents was paid for hauling and 0.43 cents was paid for placing it in position, making a total cost of 3.38 cents per pound in place.

The New Water Supplies for the Cities of the East Shore of San Francisco Bay.

By Philip E. Harroun, M. Am. Soc. C. E., Assistant Chief Engineer, People's Water Co., Oakland, Cal.

There exists to-day in the cities of Oakland, Berkeley, Alameda, Emeryville, Piedmont, and from Richmond on the north to San Leandro on the south, along the eastern shore of San Francisco Bay, a situation which is unique in the history of American water works. Before the San Francisco earthquake and fire, the population of this section was about 150,000, with a normal increase of about 18,000 per annum, and the total water supply available from all sources about 16,500,000 gal. per day. Although at that time the margin between the consumption and available supply was small, there was still sufficient reserve to provide, with care, for the normal increase in population until such time as new supplies could be developed, if promptly undertaken. Such work was begun early in April, 1906, and on April 18 the earthquake occurred. The effect of this was to immediately and permanently increase the population over 100 per cent. That there was not an immediate water famine was due to the fact it was impossible to house the people, and water was required only for their personal use. As fast as houses were built, the people became regular consumers with the normal per capita consumption and this housing has been and is progressing at the rate of 50,000 per annum.

The work begun for the development of the new supplies early in April, 1906, consisted in the organization of both office and field forces for the study of the problems involved. Work was carried on by these forces until July 20, 1906, when it was abruptly terminated owing to the two corporations supplying water having entered into a contract of sale to the People's Water Co., which contract carried no provision for the prosecution of this work. The sale was ultimately concluded Jan. 1, 1907, when engineering operations were immediately resumed and have been carried on continuously since.

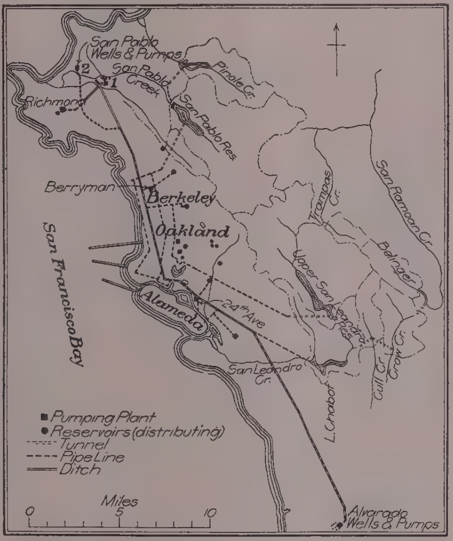
Because of the urgency of the situation, it was necessary that the general scheme for the increased supplies be determined at the inception of the work, that construction might be immediately undertaken. In consequence of this, many of the plans presented are tentative, to be modified as future investigations may indicate. This is specially true regarding the determination of those matters based on hydrographic and meteorologic studies, where the data available is insufficient for a final determination of the questions involved. These studies are still in progress and by the time it becomes necessary to make a final decision, the data will be available for the solution of the problems.

The old works and new scheme for securing the proposed increase in water supply is outlined in an accompanying map. The present supplies are drawn from Lake Chabot, and the Alvarado, Fitchburg and San Pablo No. 1 pumping plants, together with some small supplies from the high hills immediately behind the cities and serving the more thinly settled high sections.

The new project has in view the development of temporary supplies necessary to meet the increased demand until the permanent works can be put in service. This increase in the permanent supply is to be obtained through the conservation of the run-off from about 108 square miles, including Chabot, of drainage area in the hills immediately back of the cities to be supplied. Meteorological and hydrographic investigations, carried to date, have provisionally indicated that on 80 per cent. conservation of the run-off the net increased yield will be 21,000,000 gal. daily. This is based on the recurrence of the most unfavorable seventeen-year rainfall period which has occurred since 1849. This increase will give a total yielding capacity for the entire system of about 37,000,000 gal. daily.

On Pinole, San Pablo and San Leandro Creeks, as indicated on the map, large reservoirs are to be constructed. The San Pablo and Pinole Reservoirs being at the same elevation, will be inter-connected and to a great extent act as one. Into the upper San Leandro Reservoir will be diverted the run-off from the 2.64 sq. miles drainage area of Las Trampas Creek. In order to compensate Lake Chabot for the drainage area cut off by Upper San Leandro Reservoir, there will be diverted into it the run-off from 4.42 sq. miles of the Bolinger Creek watershed, 8.47 sq. miles of the Crow Creek watershed, and 4.42 sq. miles of the Cull Creek watershed. The system will thus consist of four large reservoirs with their tributary drainage areas as follows: Lake Chabot (in service), 29.56 sq. miles; Upper San Leandro, 32.94 sq. miles; San Pablo, including Wild Cat, 35.25 sq. miles; Pinole, 10.50 sq. miles; making a total of 108.25 sq. miles.

In delivering these supplies to the distribution system, it has been decided to tunnel directly through the high intervening mountains of the Coast Range instead of using long-pipe lines or open conduits, as would otherwise be necessary in following the natural contours of the Bay drainage. This gives an ideal delivery, as such construction is as permanent as human effort can make it, is as little liable to interruption from earthquake or other cause as any construction can be made; and especially from the very short distance thus secured between the reservoirs and the distribution system it gives the great advantage of bringing the supplies held in these reservoirs at once to the distribution point, making it possible to distribute by gravity over a much larger area than it otherwise would and giving much greater and more effective pressures.



Map of Oakland and Vicinity.

It will also be observed that the reservoirs group themselves into two large divisions, north and south, immediately contiguous to and discharging into opposite ends of the distribution area, as practically the entire region served lies between these two major sources. In consequence of this, all large pipes of the distribution system will be fed from both ends, much increasing their effectiveness and making it possible to close off either source, if necessary, without cutting off the supply in any section, and making it practically impossible to interrupt the supply through earthquake, fire or other cause.

These reservoirs will serve by gravity two zones—Lake Chabot on the south, with a clear water elevation of 168 ft., as later described, is to be repumped to 198 ft., and San Pablo and Pinole, at an elevation of 198 ft., will serve all the intervening section and north to the Richmond district. Upper San Leandro Reservoir, with an outlet at an elevation of 314 ft., will serve a second zone. A third zone will be controlled from Berryman Reservoir at 503 ft. elevation, while the few sections still higher will continue to be served by the works already supplying them, supplemented by pumping from the lower zones where necessary.

The works undertaken to temporarily meet the increasing demand until the permanent structures are completed are two: the San Pablo No. 2 plant and pipe line and the Fortieth St. pump station. In the cone which extends from the point where San Pablo Creek breaks through the hills to the Bay shore there have been drilled 9-, 10- and 12-in. wells to an average depth of 436 ft. These wells are cased with riveted-steel slip-joint casing, perforated through the water-bearing strata. These wells, on individual test, gave discharges ranging from 120 to 286 gal. per minute, with one exception, where the discharge ranged between 74 and 85 gal. per minute.

The water will be raised from the wells by compressed air and discharged into an open flume in which it will flow by gravity to the sump at the pump house, from which it will be picked up by the main station pumps.

The pump-station equipment consists of two 60-in. x 16-ft. return-tubular boilers of local make taken from one of the older pumping plants, together with two 72-in. x 16-ft. 125-h.p. return-tubular Erie boilers operated at 150 lb. steam pressure. The fuel is oil delivered on cars at a siding 1,000 ft. distant, from which it is carried by pipe lines to the plant. The compressed air for pumping the wells is furnished by a 20 x 22-in. and 14 x 24-in. Sullivan straight-line compressor, with a capacity of 1,160 cu. ft. per minute at 90 lb. pressure, taking steam from the light boilers at 80. lb. The pumps consist of one 12 and 20-in. by 12.5 x 24-in. crank-and-fly-wheel tandem-compound engine of 2,000,000 gal. daily capacity, made by the Oakland Iron Works, and taken from one of the older pump stations for this temporary use; also one 14 and 30-in. by 9 x 30-in. crank-and fly-wheel cross-compound Corliss condensing engine, made by the Platt Iron Works. This latter pump has a capacity of 2,000,000 gal. daily, takes steam at a pressure of 170 lb., and operates against a head of 348 ft. Its guaranteed duty is 130,000,000 ft. lb. per 1,000 lb. steam. The proper location of this pump is the Rose St. station, where it will be used in pumping from the low service to the Berryman Reservoir. Its use for the purpose above described is only temporary. In addition to the above-mentioned items, the station is equipped with the usual auxiliaries, circulating and feed-water pumps, feed-water heaters, and so forth. The equipment is housed in a temporary corrugated-iron structure.

Twelve and one-quarter miles of 24-in. riveted-steel pipe, 3/16 in. thick, are being laid between this plant and the Claremont Reservoir. The size of the pipe has been selected with reference to its ultimate, not its temporary service, as, on completion of the permanent works, its flow will be reversed and it will be used for supplying the lower-pressure zone throughout this district.

The Fortieth and Diamond emergency work is a booster plant, taking Lake Chabot and Alvarado water from low-service mains and boosting it into that section controlled by the Claremont Reservoir. No new equipment was had for this plant, with the exception of boilers. It consists of three class 66-in x 16-ft. 100-h.p. horizontal return-tubular Atlas boilers, taking steam at 150 lb, and fitted for oil burning. The pumping engines consist of one 13 and 24 by 13.5 x 18-in. compound tandem-duplex Worthington pump, with a capacity of 2,225,000 gal. daily; one 14 and 24 by 14 x 18-in. compound tandem-duplex Deane of 2,000,000 gal. daily, and one 9 and 17 by 12 x

15-in. compound tandem-duplex Worthington of 1,500,000 gal. daily capacity, all operating condensing.

Of the permanent works, the San Pablo Reservoir will be formed by an earth dam 124 ft. high above the normal surface of the stream, while the concrete cut-off well will extend to bed rock 70 ft. below same. Its length on the crest is 1,160 ft., crest width 25 ft., and slopes up-stream from 2:1 to 3 : 1; down stream, 2 : 1, broken by a 6-ft. berm 59 ft. below the crest. The cut-off wall will be carried from bedrock to within 5 ft. of the crest, and will be backed by broken stone, which will also extend under the lower half of the dam to its toe for drainage purposes. The dam will contain 842,000 cu. yd. The flow line is 10 ft. below the crest of the dam. The wasteway consists of a concrete weir 274 ft. long on the crest, over which the flood waters spill into a funnel-shape chute leading to a horseshoe-shape tunnel 16.5 x 19.5 ft. and 1,400 ft. long, passing through solid rock around the south end of the dam to the channel below. With 5 ft. of water over the crest of the spillway the discharge will be 12,000 cu. ft. per second. The tunnel will also be connected with controlling works whereby the reservoir may be drawn down at any time. The reservoir formed by this dam has a storage capacity of 656,000,000 cu. ft.

The Pinole Reservoir will also be formed by an earth dam, 112 ft. high, 800 ft. long, and containing 425,000 cu. yd. Its cross-section and structural details are the same as those for San Pablo dam. This reservoir will have a storage capacity of 305,000,000 cu. ft.

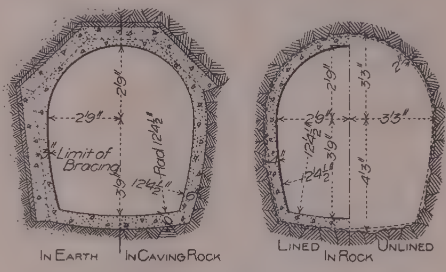
These two reservoirs are at the same elevation and will be interconnected, so that they will to a great extent act as one. The connection consists of a tunnel, 5,510 ft. long, leading out from the Pinole Reservoir with the necessary controlling works. From the southerly end of this tunnel extends a riveted-steel pressure pipe, 27 in. in diameter, to the San Pablo Reservoir. It will be observed that the Pinole Reservoir can be fed from the San Pablo Reservoir at any time when the surface of the water in the former is lower than in the latter, and vice versa, but no flow can take place from Pinole to San Pablo inlet until the latter has been depleted 12 ft. in depth below the spillway level.

The outlet from both Pinole and San Pablo Reservoir will be through a tunnel 14,660 ft. in length with a vertical shaft on Wild Cat Creek 305 ft. deep through which, after having served construction purposes, will be received the waters of Wild Cat Creek. This tunnel will deliver the water to the filter plant and distribution system at North Berkeley. In this case, as is also true of the other tunnels, the hydraulic requirements are met by adapting as small a section as it is possible to drive. As the element of time is also of great importance, that section has been adopted which will permit of maximum progress at least cost considering the materials to be penetrated. This is of the 5.5 x 6.5-ft. horseshoe-form, shown in an accompanying illustration.

Power for driving this tunnel will be furnished by a plant erected at the North Berkeley portal where fuel oil can be had by a 6,500-ft. haul from the railroad. From this plant power will be transmitted to the Wild Cat shaft and San Pablo portals as required. The major power will be compressed air, selected on account of its safety and flexibility, but primarily because pipe for its transmission was already in stock. It will be used for operating the drills in the headings, traction, pumping, hoisting and so forth, while electricity will supplement it for lighting buildings, tunnels, operating the ventilating-fan motors, for high-pressure traction compressors and also crushers and rolls for producing broken stone and sand for tunnel lining.

The power-plant installation consists of six 72-in. x 16-in. horizontal return-tubular 125-h.p. Atlas boilers, fitted for oil burning; with this fuel it will be possible for the boilers to carry 50 per cent. overload. The air installation consists of one 15 and 28 x 25¼ and 16¼ x 16-in. Ingersoll-Sergeant Myervalve compound compressor, and one 14 and 24 x 22 and 13 x 20-in. Rand Imperial Meyervalve cross-compound fly-wheel compressor, with a combined capacity of 2,524 cu. ft. of free air per minute to 110 lb. pressure. The electrical installation consists of two 100 k.v.a., three-phase, 60-cycle, 2,200-volt, alternating-current Crocker-Wheeler generators, driven by two 14 x 20-in. self-contained automatic heavy-duty 155-h.p. Brownell engines. There is also the usual equipment of auxiliaries, feed-water heater, circulating and boiler feed pumps, switchboards, and so forth.

Muck will be handled by three compressed-air locomotives, two operating through the two portals and the third serving the two headings driven from the shaft. Compressed air will be taken from the air main at line pressure and by three boosters raised to 1,000 lb. per square inch for locomotive use. The locomotive tank capacity is sufficient for one round trip on full charge. The boosters, except that at the Berkeley portal which is steam-driven, are electrically-driven by motors taking current from the main station transmission lines.



Typical Tunnel Sections.

The shaft at Wild Cat is a three-compartment shaft, two for the mine cages and the third for air and electric transmission lines, force mains from pit and heading pumps, ventilation and ladder. The mine cages will be operated by a 10 x 12-in. two-cylinder double-drum two-compartment 50-h.p. Lidgerwood hoist. The air used in this hoist and for pit pumping will be reheated, from which an economy of about 25 per cent. is expected.

The Upper San Leandro Dam will have a height of 192.5 ft. above the bed of the creek and will be 675 ft. long on the crest. It will be straight in plan with a gravity section. The provisional plan provides for a top width of 15 ft., a straight back and battered face at 0.68 to 1, the thickness at the stream bed being 125.8 ft. The top of the dam will be 7.5 ft. above the spillway crest. The spillway will be of the same type as that designed for the San Pablo and Pinole structures, the tunnel passing through the ridge under the south abutment.

This dam will form a reservoir covering 1,100 acres, with a depth of 185 ft. of water at dam, and having a storage capacity of 2,232,000,000 cu. ft. As shown on the map, the run-off from 2.64 square miles of the drainage area of Las Trampas Creek will be diverted by a small dam and led by 5,000 ft. of open conduit to the head-waters of San Leandro Creek, whence it will flow by gravity to this reservoir.

The water will be brought from Upper San Leandro Reservoir directly through the hills to the distribution system by means of a tunnel, 12,400 ft. long, which will have a shaft on Grass Creek 170 ft. deep. This tunnel will be of the same size as those for San Pablo and Pinole, and will be driven in a similar way. From the tunnel outlet a gravity conduit will lead to a filter plant above Melrose, from which a pressure pipe is to lead to Claremont Reservoir with outlet connection to Central Reservoir.

The Cull-Crow-Bolinger system consists of diverting the run-off from 4.92 square miles of the Bolinger shed into Crow Creek, picking up the same, together with the Crow Creek waters, and passing them into Lake Chabot by tunnels, intercepting on the way the Cull Creek waters. The equalizing and diverting dam on Bolinger will have a maximum height of 60 ft. It will be a composite structure of earth and concrete forming an equalizing reservoir of 15,000,000 cu. ft. capacity. From this reservoir the waters will be carried in an open conduit about two miles long, thence through a tunnel, 1,620 ft. long, will enter the Crow Creek watershed. From this point it will flow by gravity down the natural stream channel to the Crow Creek Dam.

The diverting Dam on Crow Creek will be 60 ft. high and 740 ft. long. Its character and slopes will be similar to the San Pablo and Pinole structures. The equalizing reservoir formed by this dam will have a capacity of 24,000,000 cu. ft. From this reservoir the water will pass into San Leandro Creek, picking up the Cull waters on the way through a shaft 125 ft. deep. The Cull diversion will be effected by a composite dam 35 ft. high and 290 ft. long. This dam will create a precipitating and equalizing reservoir with a capacity of 6,700,000 cu. ft., from which an open conduit, 500 ft. long, will conduct the water to the tunnel shaft.

The Crow-Cull-San Leandro tunnel will have a length of 12,920 ft., and is 5½ x 6½-ft. in section, as are the others previously described. The construction scheme and plant will be identical with the others, modified only in minor features to meet local requirements. Here the power house will be located at the Cull Creek shaft, from which power will be transmitted to both the San Leandro and Crow portals. As the power plant will be about eight miles from the railroad, and the country roads are practically impassable during the wet season, a 1,000,000-gal. fuel-oil storage reservoir is to be constructed, holding sufficient oil to carry the power plant through the period.

Three filter plants will be constructed, one at Lake Chabot to replace the present inadequate plant; the second back of Melrose in the hills at an elevation of about 325 ft. to handle the water from the Upper San Leandro Reservoir, and the third at the North Berkeley portal of the San Pablo tunnel to handle the waters from the San Pablo and Pinole Reservoirs. The open, rapid-mechanical type will probably be adopted, but final decision on this matter, as well as the details and plans, will not be reached until the completion, early in the summer, of the experimental runs.

The capacities of the filter plants will closely approximate the following requirements:

	Summer capacity, mil. gal. daily.	Winter capacity, mil. gal. daily.
Chabot	15.4	12.7
North Berkeley	16.6	13.7
Melrose	7.25	6.0

In order to increase the storage capacity within the limits of the cities and also to raise the pressure derived from Lake Chabot and the Alvarado sources, the Central Reservoir is to be built. This reservoir has a high-water elevation of 198 ft. and a capacity of 150,000,000 gal. It will be concrete lined and covered with a timber roof. This reservoir having an elevation the same as that proposed for the clear-water basin of the North Berkeley filter plant, will admit of the entire intervening territory being supplied under a common pressure from these two independent sources.

To boost the Lake Chabot and Alvarado waters to this reservoir, the Twenty-fourth Ave. pumping station is being built, with a capacity of 24,000,000 gal. daily. The equipment consists of three 150-h.p. water-tube boilers, having 1,550 sq. ft. of heating surface and furnishing steam at 175 lb. pressure. The pumping engines consist of three horizontal cross-compound condensing Reynolds Corliss type duplex double-action pumps 16 and 36 x 16¾ x 36-in., each of 8,000,000 gal. capacity, against a head of 134 ft. They are made by the Allis-Chalmers Co., and have a guaranteed duty of 135,000,000 ft.-lb. per 1,000 lb. of steam. The station is equipped with a Crocker-Wheeler 7½-kw generating set, driven by a 5 x 4-in. Ohmen engine; a small Westinghouse air compressor for charging air chambers, together with the usual auxiliaries. Fuel oil will be used.

The distribution system is to be rearranged as shown on the map by laying large interconnecting pipes between the various reservoirs and pumping plants.

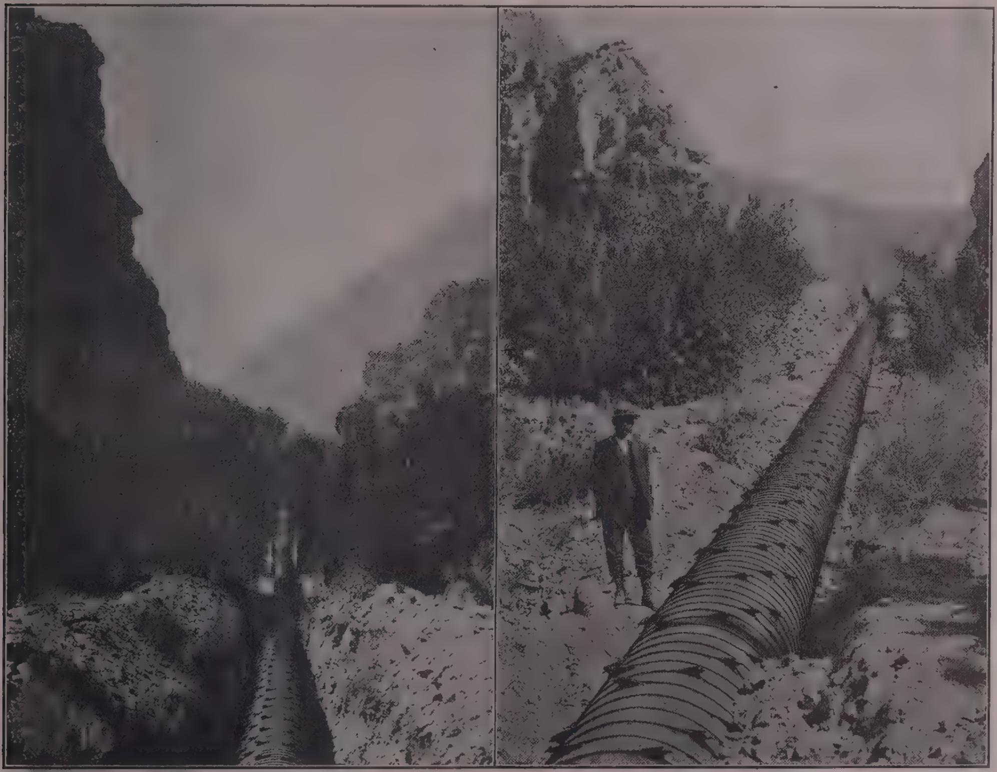
This work has been carried on under an organization consisting of Mr. Arthur L. Adams, M. Am. Soc. C. E., chief engineer; Mr. Philip E. Harroun, M. Am. Soc. C. E., assistant chief engineer; Messrs F. T. Oakley, M. Am. Soc. C. E.; W. W. DeBerard, Assoc. M. Am. Soc. C. E.; G. C. Stevens, Langdon Pearse, Jun. Am. Soc. C. E., and August Kempkey, Jr., Jun. Am. Soc. C. E., assistant engineers, together with the necessary field and office forces.

An Interesting Salvage Operation was carried on in the River Mersey, England, in raising the coaling barge "Pensarn," which is fitted above its flat deck with a steel tower 96 ft. 6 in. high, from which cantilever arms project so as to reach over the hatchways of vessels. The usual practice of caulking the defective seams, sealing the hatchways, and then pumping out was not followed, because, as stated in "The Enginner," London, the weight of 16 ft. of water above the flat deck was too great for it to support. The Liverpool Salvage Association, which did the work, built a cofferdam 50 ft. long and 20 ft. deep on the deck, surrounding the hatchways and the steel tower, and after caulking the seams both the cofferdam and the hold were pumped out at the same time. The cofferdam was built in 6 x 20 ft. sections, the lower ends of which were bolted to a log base which the divers had previously secured to the deck. The sections were built on shore and floated to place.

A Hydro-Electric Development in American Fork Canyon, Utah.

By A. P. Merrill, Salt Lake City, Utah.

American Fork River, one of the tributaries of Utah Lake, in Utah County, Utah, drains about 60 square miles of rough, broken country, which comprises portions of the western slopes of the Wasatch Mountains. There are no storage sites in this district, and the stream flows rapidly down a steep, narrow and rugged canyon. The normal flow is supplied by springs fed by the winter snow which caps the mountains between the months of November and June following. The United States Geological Survey maintained a gaging station on this river near the mouth of the canyon from 1900 to 1905, inclusive. This period was marked by an unusually low cycle of rainfall. The lowest flow recorded for this stream was 11 cu. ft. per second, while the highest was 582 cu. ft. per second. The period of maximum is during May and June, while the low-water period is between August and December, but sometimes extends to February. However, the average low-water flow is seldom below 20 cu. ft. per second, and during the past two years the minimum flow was undoubtedly more than double this figure.



Wood-Stave Pipe Line of the Utah County Light & Power Company Development.

Seven years ago the Utah County Light & Power Co. installed a 1,000-h.p. plant five miles northeast of the village of American Fork, at the mouth of American Fork Canyon. The tail-race of this plant is just above the intake of several canals. The plant has been in continuous operation since that time, the energy developed being used for lighting and power purposes.

The company soon found that the demands made on it for power exceeded the capacity of this small plant during the low-water season, so a steam auxiliary was installed. It was intended to operate the steam plant only in times of accident and during extreme low-water period. However, it was only a short time before it was found that it would be necessary either to operate the steam plant continuously, or to develop one of the power possibilities farther up the canyon. Owing to the high price of coal in that locality, the latter course was chosen.

The site for the upper plant was so chosen that its tail-race was just above the intake of the lower plant, and it will operate, under normal conditions, under a net head of approximately 520 ft. This involved the construction of two miles of continuous wood-stave pipe and 600 ft. of riveted-steel pipe. There were no existing water rights which could be molested, and the acquirement of power rights meant merely conforming to the requirements of the State engineer, and securing the necessary right of way from the national authorities, as the pipe line is on a forest reserve.

Headworks.—The overflow weir and intake are constructed of timber. Three main sills, 12 x 12-in. by 45-ft., placed 5 ft. 9 in. center to center, were laid across the stream bed and into the banks. To these, on the left side and across the original stream bed, was nailed the flooring of 2 x 12-in. planks. The weir posts are 5.5 ft. high above this floor and they are capped with two layers of 3 x 14-in. planks. These posts are bolted to the up-stream sill, and they are braced to the middle sill by 10 x 10-in. braces.

On the up-stream side an apron 5 ft. long extends into the stream bed at an angle of 30 deg. with the horizontal. At the extreme left is built the timber wing walls, the direction of which is 45 deg. from the center line of the stream bed. The bank in front of these walls is rip-rapped.

The intake is on the right side of the stream and is placed on the same sills as the floor below the weir. The regulating gate is 8 ft. wide and is in line with the weir, but on the up-stream side of this gate is a chamber which the water enters through a screen consisting of 1-in. bars, 4 in. apart on centers. This chamber is triangular in shape, being really an enclosure between the regulating gate and a wing wall in which the screen is placed.

A flume 40 ft. long is constructed below the regulating gate, and at the lower end of this flume is another chamber, which the water enters through an iron screen made of ⅜ x 6-in. bars, placed 1½ in. apart on centers. This screen is inclined, the lower end resting on a wall 2.5 ft. high across the flume. This wall virtually makes a sand box of the flume between the regulating gate and the lower screen, which box is flushed out by a small sluice gate placed just in front of the bottom of the screen. A spillway is also provided on the side of this flume. This means, therefore, that the regulating gate need not be adjusted exactly to the needs of the plant, as the excess water flows over the weir. But in times of a shut-down it takes the place of a gate at the end of the pipe which enters the chamber at the lower end of the flume. The end of the pipe is thus left open and a stand-pipe, which would otherwise be needed to avoid vacuum difficulties, is precluded.

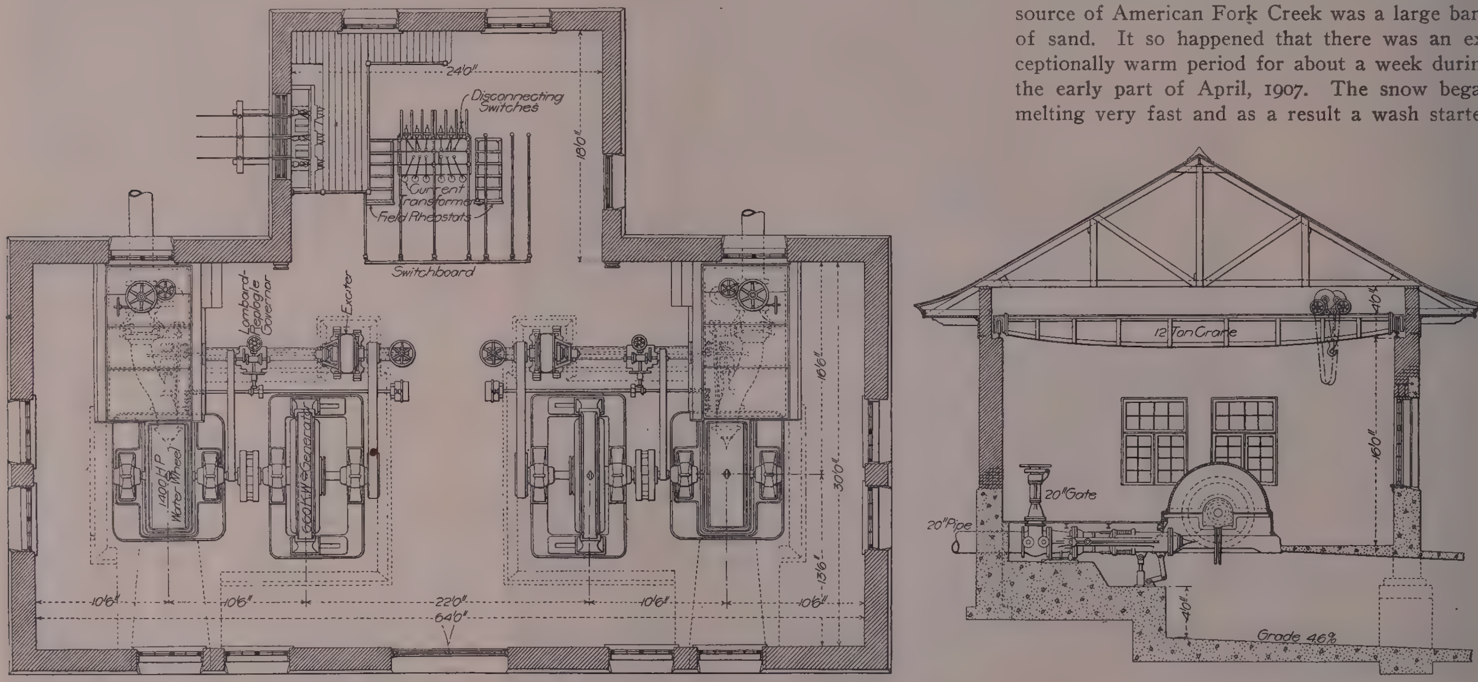
Between the main overflow weir and the flume is a sluice gate 5 ft. wide. This gate is kept partially open during high water in order to keep the gravel bed below the level of the upper screen. This was necessary, for, during high water, the flow of the stream is several times that normally used for power and the velocity is so high that the water carries sand and gravel, in addition to a large amount of wood. At the company's lower plant these materials carried during floods have given rise to considerable trouble, necessitating, among other things, the frequent renewal of broken wheel buckets. The new head-works were designed especially to overcome this difficulty, and with the main sluice gate located where it is, besides the two screens and the large sand box below the regulating gate, little trouble is anticipated from this source.

Continuous Wood-Stave Pipe.—Where conditions justified, the continuous wood-stave pipe was laid on a grade as near the hydraulic grade as it was thought advisable, when considering the necessity of keeping the pipe filled. It was found necessary, however, to construct three inverted siphons, the first and longest one being at the upper end of the line where the pipe follows down the bottom of the canyon for some distance; the other two are about midway between the point of diversion and the power house. The maximum head on this pipe at one of the siphons is 175 ft.

The remaining portion of this line was laid on a table cut on a grade contour along the mountain side. As the canyon is rough and broken, this alignment necessitated the introduction of many curves, some of which were quite sharp, and the driving of eleven tunnels through solid quartzite ledges, the length of the tunnels varying from 25 to 160 ft. The tunnels were rectangular in shape, the dimensions being 4 x 5 ft., and some of them were located on curves.

The pipe is 36 in. in diameter, and a section at right-angles to its axis shows 22 staves. These staves were sawed from well-seasoned Oregon fir, with their faces dressed to true segments of circles and the edges to true radial lines. They are 1⅝ in. thick, but vary in length from 8 to 15 ft.

In making the joints a special malleable casting patented by Mr. Frank C. Kelsey was used. A section through this casting is similar in shape to that of an I-beam, except that there is a shorter flange projecting from the middle of the web on either side. The distance between the outer edges of the main flanges corresponds with the thickness of the staves, but one of them has a batter of 1/32 in. This means that when in place the outer flanges project over the ends of the stave, compressing it 1/32 in., while the smaller middle triangular flanges are driven into them. The flanges of this casting are longer than the web, so they not only project over the two ends of the staves, but also over the side adjoining staves.



Plan and Cross-Sectional Elevation of Power House Building.

The bands are ½ in. in diameter and have square heads, with upset threaded ends. The foreman on the work was provided with a sheet showing the required band spacing for the various portions of the pipe, the spacing having first been calculated for the given pressure.

The coupling has a curved seat, which sets on the outside of the stave, and two lugs so designed that they will hold both the head and nut of the band. The shape of the coupling can be seen in one of the illustrations.

The staves were hauled as near to the work as possible in wagons. From this point in the bottom of the canyon a narrow T-rail track was laid up the mountain side to the grade. The cars containing the bands, staves, and so forth, were drawn up the track by a horse which was worked back and forth along the table cut for the pipe.

All castings and steel bands were dipped in a special paint before being used. This was done in the bottom of the canyon near the lower end of the track.

Construction was quite difficult in many places, especially at the two lower siphons and in the tunnels located on the curves. In building the pipe around curves, short straight lengths from 50 to 75 ft. long were first constructed, only enough bands being used to hold the staves in place. It was then shifted into the proper place with jacks. In doing this some of the staves tended to slide longitudinally, which condition required driving them to place from the end of the pipe with heavy mallets. The rest of the required number of bands were then placed. When the bands were first placed around the dry staves they were made just tight enough to hold the pipe together. After the water had been turned in, and the staves became fairly well saturated, all bands were tightened. But at no time were they drawn so tight that the fiber of the wood was cut or crushed. The second tightening of the bands stopped practically all leaks, there being none in the two miles of pipe of any importance, and only a small number of minor ones where the pressure was highest.

Air vents or stand pipes were placed at all summits, and washout valves at the lowest point in the siphons. It is expected that much of the sediment that succeeds in passing the head-works will settle in the siphons, where it can be washed out and its deteriorating effects on the machinery will be avoided.

Steel Pipe.—The continuous wood-stave pipe ends in a specially-designed cast-iron hub on the mountain side about 575 ft. directly back of the power house. From this hub a 36-in. lap-riveted steel pipe extends for 300 ft. to a reducer, beyond which is 247 ft. of 33 in. pipe to a Y-connection near the power house. From this point two 20-in. branches connect with the valves just inside of the building. There are two curves required in the alignment of each of these branches, one in a vertical plane just outside of the building and one in an inclined plane, which connects with the tangent extending to the Y. The steel pipe was made in 5-ft. sections, the different sections being lap-riveted together, and was shipped from the factory in 20-ft. lengths. The Y is set in a large concrete block, which is securely anchored to the ledge at that point. There are also concrete blocks just behind the building to which the branch pipes are anchored.

Power House Building.—A concrete retaining wall is built along the right river bank to protect the building site. The building is located between this wall and the foot of the mountain. The tailraces discharge directly into the intake of the pipe line for the lower plant. The building foundations are of concrete, this material being used up to the water table, as shown on the drawing. Above this level the walls are of brick. It is evident from the plan presented that the building is well lighted. Reinforced concrete lintels are used over all openings. The inside is plastered and the floors are of concrete. As shown in the section through the building, provision is made for supporting a 12-ton crane. A hipped roof was adopted, and the drawing showing the section of the building indicates the construction.

Machinery Foundations.—The machinery foundations are of concrete composed of one part cement, three parts sand and four parts broken stone. The company was unusually fortunate in obtaining the sand and stone. Just across the creek opposite the power house were some large limestone slides from which sufficient quantities of stone were readily obtained, while near the source of American Fork Creek was a large bank of sand. It so happened that there was an exceptionally warm period for about a week during the early part of April, 1907. The snow began melting very fast and as a result a wash started through this sand bank. By making temporary provision for decreasing the speed of the water near the power house, the company obtained most of the sand required by merely shoveling it from the creek bed as it was carried down. It was thrown on a sloping bridge across the stream which readily drained it. The sand thus obtained was hard, clean, sharp and fairly coarse.

The method used in placing foundations and setting the anchor bolts was as follows: The pit for each unit was excavated and the outside forms placed. After the concrete was brought nearly to the head of the foundation bolts the necessary framework was placed on top of the outside forms and on this was laid the water-wheel and generator templets. The foundation bolts were then supported in the templets and their tops brought to the proper elevation with the level. In order to obtain the proper alignment for the templets, small nails were securely fastened on the end walls in a point on the line traced by a vertical plane through the shaft line. A No. 20 steel wire was stretched between these nails. Lines at right-angles to this one, which corresponded with the center lines of the machines, were also strung. The templets were then located in their proper places by means of plumb-bobs supported from the wires.

The lower end of each foundation bolt was set rigidly in the concrete, but the upper ends were allowed 1-in. play in every direction by keeping a piece of tile pipe over the bolt and working it up after the concrete had set sufficiently. The holes were filled with grout after the machines were in place.

Machinery.—The arrangement of the machinery is shown on the accompanying plan. The Pelton Water Wheel Co. furnished the water-wheels, which are of 1,400-h.p. capacity each, and the valves and nozzles. As the maximum static head is a little over 600 ft., it was necessary to provide a by-pass and an auxiliary slow-motion gearing on the valve. The nozzle is curved in a horizontal plane, and it is balanced by a piston acting in a hydraulic cylinder, which is connected to the pressure pipe back of the valve.

The amount of water striking the buckets may be regulated in two ways. The needle in the nozzle is geared to the hand-wheel, which stands near the switchboard, thus enabling the attendant to control the quantity of water passing through the nozzle. The nozzle also has a 30 deg. motion in a vertical plane, and this allows the governor to deflect a portion of the water from the buckets. This governor can be disconnected if desired, and the nozzle is then deflected by operating the hand lever, also near the switchboard. By thus deflecting the water, irrigation requirements are undisturbed and the undesirable effects of water ram are overcome.

Bascule Bridge at Peoria, Ill.

The electrical equipment was furnished by the Westinghouse Electric & Mfg. Co. The generators run at 300 r.p.m. and are connected to the water-wheels by a flexible leather coupling. They are 600-kw., 6,600-volt, 60-cycle, three-phase, revolving-field machines. The exciters, belted to the generators, run at 725 r.p.m. Each exciter has sufficient capacity to furnish current for both generators if required. They also supply lights for the plant and the cottage near by.

Switchboard and Instruments.—The switchboard contains five Westinghouse standard panels, the total length being 11 ft. 8 in. and the height 7 ft. 6 in. A synchroscope is supported on the bracket at the side of the board. All instruments are connected through the secondaries of small instrument transformers. For each generator there are three ammeters, a wattmeter, a voltmeter, a frequency meter and an over-load reverse-current relay, besides the necessary handles for oil circuit-breakers, field switches and resistances. In each exciter circuit there is an ammeter, a voltmeter, a circuit-breaker, besides the shunt-field and equalizer rheostats. The two exciters are also connected to an equalizer bus.

A graphic recording wattmeter and a graphic recording power-factor meter are connected to the feeders. Choke coils and lightning arresters are also placed in the line just inside of the building. A Type-T. A. Terrill regulator is connected to the feeder buses on one side and the exciter buses and terminals on the other. With the water-wheel governor on the hydraulic side, and the voltage regulators on the electrical side, it is expected that quite close voltage regulation at the power house can be obtained.

Miscellaneous.—The plant is six miles from the nearest railroad station, which necessitated considerable teaming to get materials to the site. Part of the haul was over a narrow canyon road over which part of the heavier equipment was moved with some difficulty.

The work was done on force account, the company employing and supervising its own labor. The grading was begun in May, 1906, and the plant was practically completed in November 1907. A 42-mile transmission line is now being run to the smelter and mines in the Tintic District. A new transformer house is now being built near the old plant at the mouth of the canyon. The transformers will be supplied with current from both plants at 6,600 volts, which will be stepped up to 44,000 volts.

The plant has not yet been loaded to its normal load, but is has supplied a small amount of power for lighting purposes. A complete efficiency test of the plant has not yet been made.

Messrs. Willard Young and Frank C. Kelsey were the engineers employed by the company, and the plans and specifications were prepared under Mr. Kelsey's personal direction. As representatives of the engineers, Mr. A. Z. Richards made the preliminary and location surveys, and the writer prepared the foundations and set the machinery. Mr. J. H. Wootton, manager of the company, had general supervision of the work.

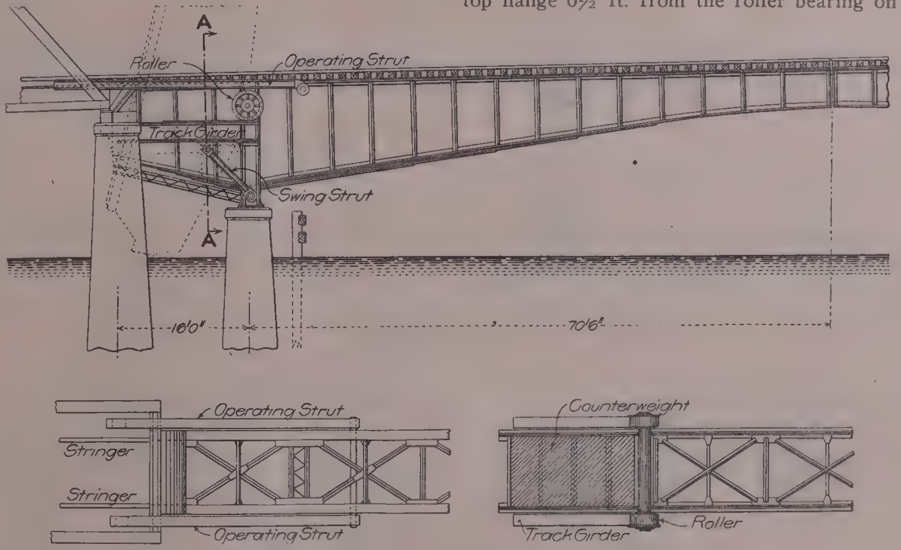
Municipal Ownership of Coal Mines has been discussed for some months in the city council of Vienna, Austria, and it is reported that the city is now trying to secure control of mines in Moravia. The reasons given for the purchase are the high price of coal and the difficulty of securing a steady supply for the municipal gas and electrical plants.

Bascule Bridge of the Rall Type at Peoria, Ill.

The single track of the McKinley interurban syndicate is carried across the Illinois River at Peoria, Ill., on a double leaf plate girder bascule bridge with a clear opening of 125 ft. between protections which are on lines slightly skewed with the axis of the bridge. This bridge, which was recently put in service, is the second constructed of the Rall type and presents some interesting features in the general design, details and methods of operation.

It is a deck structure with two movable platforms, each 12 ft. wide and 83½ ft. long which, when the bridge is in service, form cantilevers located together in the center of the channel. Each platform has two full-length plate girders forming cantilevers fulcrumed and pivoted on the main piers 17 ft. 5 in. from the extremities of the anchor arms and 70 ft. 6 in. from the extremities of the cantilever arms and having depths decreasing from about 12 ft. over all at the fulcrum to 4 ft. at the cantilever end and 8 ft. 6 in. at the anchor end.

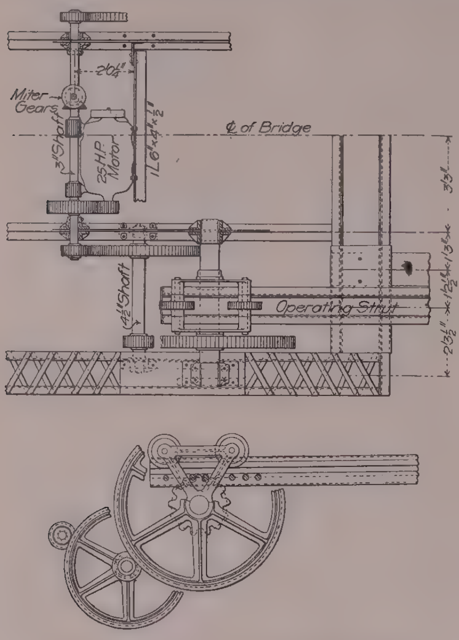
A transverse horizontal shaft passes through the webs of both girders of each leaf in the vertical plane of the fulcrum when the girder is in the closed or horizontal position. The extremities of these shafts carry large rollers, outside the girder webs, which take bearing on horizontal tracks about 17 ft. 6 in. long. The anchor arm of each girder is connected to the fulcrum by a swing strut pivoted at both ends, which when the girder is horizontal is inclined about 45 deg. from the vertical. A horizontal operating strut about 31 ft. long, on the outside of the girder, has one end pivoted to the web near the top flange 6½ ft. from the roller bearing on the cantilever side and extends beyond the end of the anchor arm to engagement with the operating machinery.



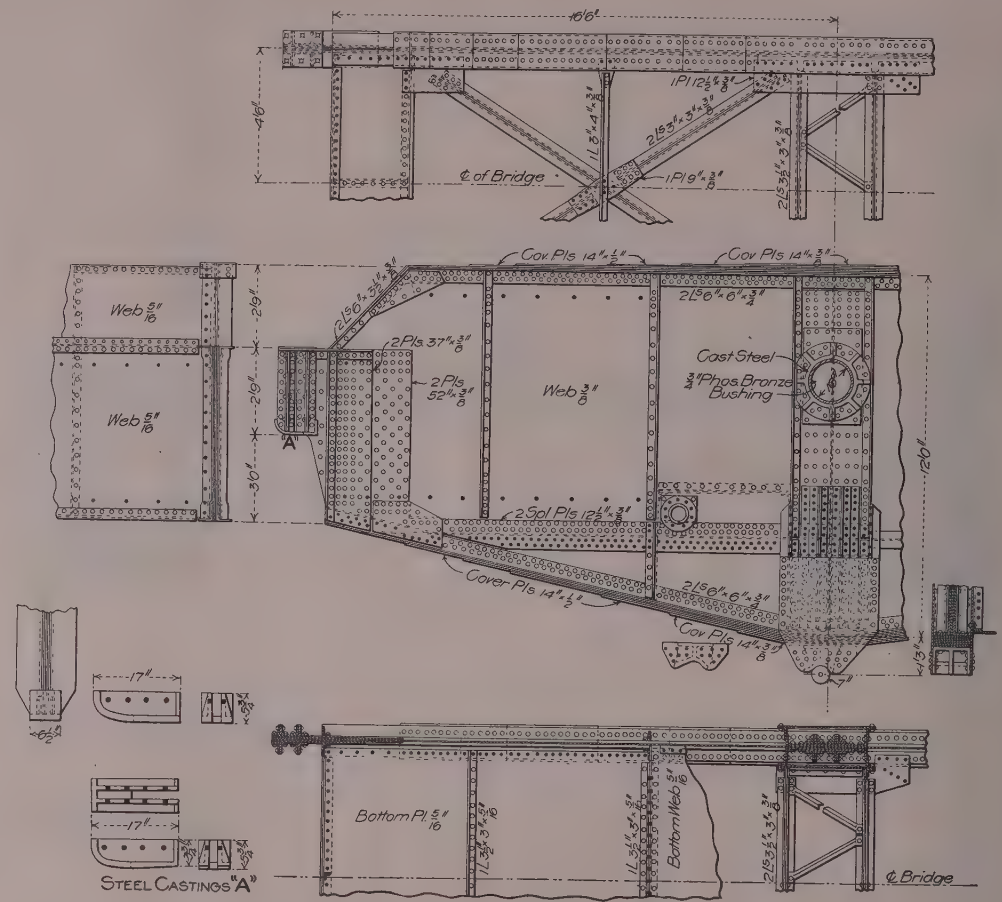
Semi-Elevation of Span, Peoria Bascule Bridge.

In order to revolve the girders into a nearly vertical position and open the bridge for navigation, the operating struts are pulled horizontally toward the shore and the girders correspondingly rolled shoreward with their centers of gravity maintained in the same horizontal line through the axis of the roller. At the same time the swinging struts engaging the anchor ends of the girders, revolve and their action combined with that of the longitudinal motion, throws the anchor arm downward and revolves the cantilever arms upward into the required positions indicated by the dotted lines. The operating parts are few, the mechanism simple, the moving parts are in equilibrium and as their center of gravity is not moved vertically, only friction, wind, and inertia have to be overcome, and it is calculated that a 13 h.p. motor is sufficient to operate each leaf.

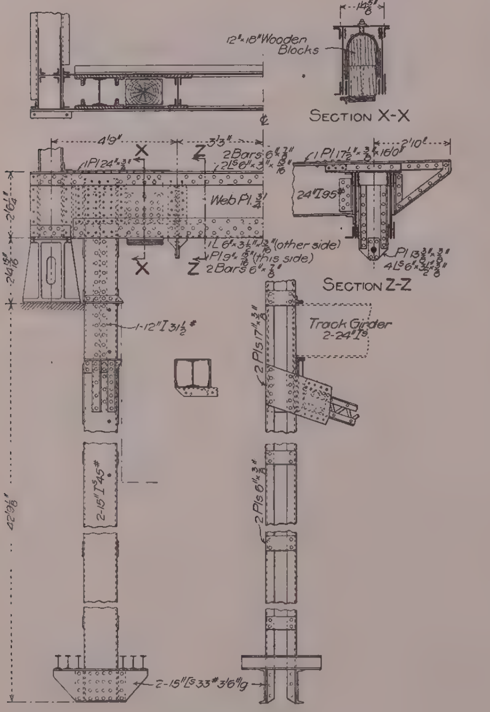
The structure is proportioned for a live load consisting of a train of 75-ton cars 40 ft. long, each with four axles spaced 6 ft., 9 ft., and 6 ft. The top lateral system is proportioned for 450 lb., and the bottom lateral system for 225 lb. horizontal wind pressure per lineal foot and the calculated dead loads of the cantilever and anchor arms are, for each girder, 44,000 lb., and 132,000 lb., with lever arms of 31 ft. 6 in. and 10 ft. 6 in. respectively. These loads give a maximum live load anchorage reaction of 345,000 lb., and a maximum fulcrum load of 675,000 lb. per each girder.



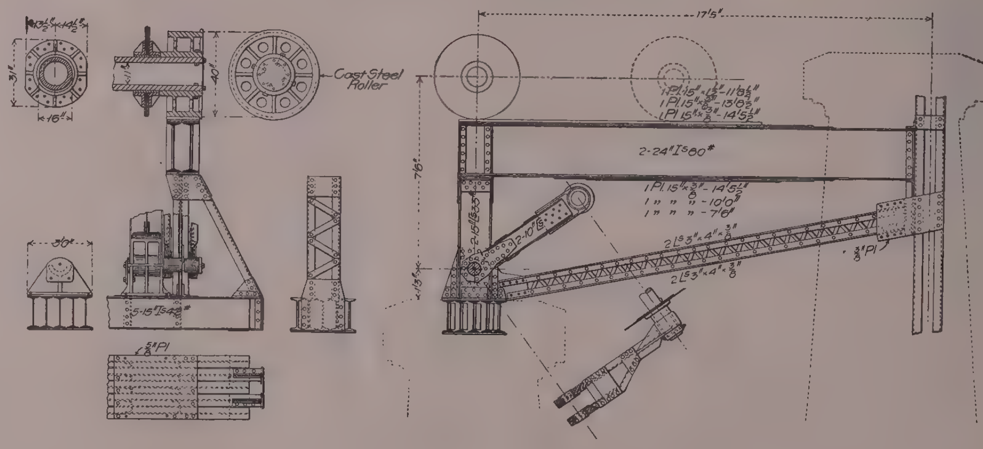
Arrangement of Operating Machinery.



Anchor Arm of Bascule Girder.



Anchorage Details.



Roller Track and Pivot Strut.

The maximum shear in each main girder is 477,000 lb., and the maximum bending moment is 7,386,900-ft. lb., which produces a flange stress of 607,000 lb. resisted by a net cross sectional area of 46.7 sq. in. The maximum stresses in the lateral diagonals are 59,000 lb., and 30,000 lb. in the top and bottom systems respectively. The maximum stress in the operating strut is 30,000 lb. and in the swing strut 36,000 lb.

The main girders have a web ⅜ in. thick throughout which is divided into panels about 5 ft. long by pairs of 5 x 3 x ⅜-in. vertical stiffener angles. The flanges are made with pairs of 6 x 6 x ¾-in. angles reinforced with six 14-in. cover plates of varying lengths increasing the net maximum cross-section to 47 sq. in. The girders are of ordinary construction except at the rear end where the anchor arms, fulcrums, and pivots, involve some special details.

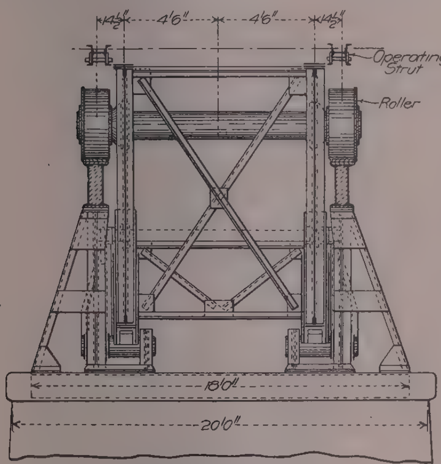
In order to provide for the very heavy load of the fulcrum bearing, the deepest part of the girder web is reinforced to a total thickness of over 2 in., for a width of about 3 ft. in the lower part, and is stiffened by 12 vertical angles with their lower ends milled to bearing on the horizontal flanges of the bottom flange angles to reinforce them against the pressure transmitted from the pivot casting, which is seated on their lower surface and is riveted between longitudinal jaw plates secured by vertical connection angles to the web stiffeners above. The pivot casting has a concave surface engaging the 7-in. pin which connects the pedestal and swinging strut. This surface, however, does not give bearing on the full projection of the pin but diverges on both sides from the cylindrical surface so as to clear the latter on a horizontal line through its center.

In the vertical plane of the fulcrum bearing, two cast-steel flanged discs with ¾-in. phosphor-bronze bushings are riveted to opposite sides of the web and are bored for the 16-in. axle of the roller. In the anchor arm the lower part of the web is similarly reinforced by two smaller flanged discs bored for the 6-in. pivot of the swinging struts. A third pair of discs 6½ ft. horizontally from the roller bearing are riveted to the web of the cantilever arm and are bored for the 7-in. pivot of the operating strut. The anchor arm of the girder web is notched top and bottom and the projecting portion is stiffened by four pairs of vertical angles which give bearing to the horizontal legs of an upper flange angle with a bearing plate which forms the seat of the girder against the stationary transverse reaction girder firmly anchored to the pier to receive the upward reaction of the bascule when in service.

The reaction girder has a rectangular cross section like that of an ordinary top chord and is made with two 30 x ¾-in. vertical web plates 16 in. apart, three 6 x 3½ x 13/16-in. flange angles, four 6 x ⅞-in. flange plates and one 9 x 13/16-in. flange plate. The ends of the girder are seated on cast-pedestals with rust joints on the masonry piers and the webs are field-riveted to the upper ends of vertical anchorage columns of rectangular cross section, made with a 12-in. I-beam and two 15-in. channels with their flanges turned in. These members are nearly 47 ft. long and at the lower ends have horizontal 15-in. channels riveted across their webs and projecting about a foot on each side to receive a set of six 7-in. horizontal reaction beams 3 ft. long imbedded in the pier masonry.

Close to the connections of the girder with the vertical anchorage column there are seats on the lower side of the girder to receive the ends of the anchor arms of the main girders. These seats are provided with horizontal adjustment plates bearing on the square lower ends of wooden blocks fitted between the webs of the reaction girder and rounded at the upper end to engage the loop of a U-plate riveted to the girder webs. This bearing acts as a bumper for the bascule girders when they reach their closed positions and the wood serves in some degree to cushion the shock or impact.

The main pivot of each bascule leaf carries a rolling load of 180,000 lb. per girder, and consists of a hollow shaft of 16 in. outside diameter and 11 in. inside diameter and about 13 ft. long. This shaft takes bearing in the reinforcement discs on the webs of the girders and projects about 19 in. beyond them to receive the cast-steel rollers 40 in. in diameter with 15-in. faces. The rollers are not keyed to the shaft but instead have short radial bolts passing through their hubs and the shell of the shaft. The open ends of the shaft are closed with steel discs stud bolted to it. The rollers have 1-in. flanges ¾ in. deep on the outer edges and move on a 15 x 1½-in. track plate 11 ft. 8½ in. long, countersunk-riveted to the top flange of a longitudinal horizontal girder about 18 ft. long made with a pair of 24-in. 80-lb. I-beams, with 15-in. top and bottom flange reinforcement plates.



Enlarged Section at AA.

The swing struts on the outside of the girder web engage at the lower ends the 7-in. main pivots through the bottoms of the vertical posts and bolsters. When the bridge is closed these pivots receive the whole dead and live load, carrying it free of the rollers which are then lifted ⅛ in. clear of their tracks.

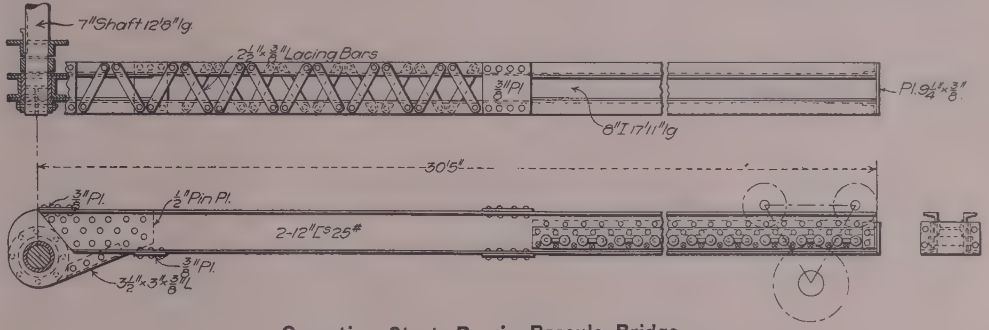
The bolsters are made with full-length grillages of five 15-in. transverse I-beams which extend across the full width of the pier and receive the cast-steel pedestal, the vertical post and the vertical post bracing.

The operating strut about 31 ft. long over all has an eccentric connection at one end made with a steel casting and brass bushing, bored to engage the 7-in. cold rolled pivot and secured in position on it by collars both sides. The opposite or shore end of the operating strut has forty 2⅝-in. horizontal transverse pins 13¼ in. long, passing through the webs and serving as teeth forming a rack which is engaged by a driving pinion as shown in the detail. A pair of friction rollers 14¼ in. in diameter are connected to the pivot of the driving pinion and engage the upper horizontal surface of the operating strut so as to hold it always in engagement with the pinion.

The operating mechanisms for each leaf of the bascule are independent and consist merely of one 25-h.p. General Electric motor driving a transverse horizontal shaft with gears at both ends and a system of gearing connecting them to the operating struts. The main shaft is also provided with a miter gear and hand lever for operating it should the electric mechanism be disabled. The space between the anchor arms of the main girders in the bascule is enclosed by steel plates forming a box which is filled with about 250,000 lb. of pig iron and concrete for each leaf, serving as counterweights to balance the girder on the trunions. Suitable locks operated by small motors and controlled by automatic signals are provided for the cantilever arms and for the tail arms, and the bridge can be opened or closed in three-quarters of a minute with electric power and within two minutes by hand power.

Mr. Ralph Modjeski is the engineer for the McKinley syndicate and the structure was designed and erected by the Strobel Steel Construction Co., Chicago. The structural steel work was fabricated by the Mount Vernon Bridge Co. The machinery was furnished by Chalmers & Williams, Chicago.

The special advantages claimed for this type of bascule bridge, are, First, that for the bridge closed, the length of span is a minimum and equal to the distance from center to center of river piers. Second, the length of travel of the bridge is a minimum and is only just sufficient for the tail-part containing the counterweight to clear the river pier when the bridge is fully opened. Third, that the shop work on the bridge is simple and easily built. Fourth, that the rollers on which the bridge moves are solid steel castings with smooth tread which can be made of any suitable proportions and are smooth and noiseless in their operation. Fifth, that the track girders are simple and, for this case, heavy I-beams. Sixth, that either the rollers or track girders can be easily removed for repairs or changes because they are not under strain when the bridge is in service.



Operating Strut, Peoria Bascule Bridge.

The bridge was completed and put in service April 1, 1807, and is the second of the type constructed, a single leaf bascule of 26-ft. span ot Delphos, O., being the first. Four double-track bridges of the same type for Trunk lines are now under construction by the same builders, the Strobel Steel Construction Co.

THE TRAFFIC PROBLEM IN BERLIN has become so acute that the town council has voted $20,000 as a prize for the best plan of laying out future additions to the city with a view of distributing the traffic. The congestion is particularly acute in the Leipzigerstrasse, and plans are being considered for diverting cars and vehicles to parallel streets. It is also proposed to tunnel under the Potsdamer Bahnhof, which cuts off communication between busy parts of the town.

A Window-Cleaning Traveler for the Carnegie Library, Pittsburg, Pa.

In the recent reconstruction and extension of the Carnegie Library at Pittsburg, Pa., special study was made of the most approved methods of the care and preservation of the volumes of the large library in view of the prevailing dirty and sooty condition of the atmosphere in that city. As it appeared that the most effective results might be obtained with the books kept in as pure and clean an atmosphere as possible, a book stack division was erected which is isolated from the remainder of the building and fitted with special equipment for thorough ventilation, that utilizes an air washing apparatus for clean air supply, as described in an article upon the ventilating equipment of the library extension in The Engineering Record for Oct. 26, 1906. As a further precaution against the admission of the unclean outer air into this section of the building, for additional ventilation or otherwise, all the windows of the book stack division were installed in single large lights and hermetically sealed. This arrangement, while particularly effective for the principal purpose involved, introduced a difficulty of no little magnitude in the cleaning of the outer surfaces of the windows. As no ledges or other means of access to the outer sides of the windows had been provided in the architectural considerations, and as it was particularly undesirable to resort to any means of opening the windows for this purpose, resort was finally had to a suggestion as to the feasibility of arranging traveling elevators outside the wall to permit of access by the cleaners to the outer window surfaces, which was finally successfully worked out.

The book stack section of the building is a wing 40 x 120 ft. in plan that extends across the large interior court space between the museum division at the rear or southerly end of the building, to the hall of architecture division in the central front portion, which wing is connected with the main library division on the westerly side by a wing of similar width extending at right angles to it, forming thereby three interior courts. This wing was designed with special reference to its use for book storage only, and is 11 stories in height, rising 84 ft. above the first floor level. The stories are, as best adapted to the stacks, of low headroom, the floor heights being for the greater part about 7 ft., excepting on the 4th and 8th floor levels where constructional details of the building required floor heights of 10½ ft. The wing is fitted for profuse window lighting, single-light windows, 3 x 5¼ ft. in size, being placed at frequent intervals in both side walls at every floor level and, for the reasons above mentioned, all of the window sash are permanently fastened in place with no provisions for opening for any purpose whatever.

The suggestion was offered by the architects of the Library Extension, Messrs. Alden & Harlow, Pittsburg, Pa., that a form of light window cleaning traveler be devised, for operation in a manner similar to that of certain traveling fire escapes that have been built, and carrying a light hand-operated elevator car for the window cleaners, thus giving access to every window on the side of the building. The design of this traveling elevator equipment was placed in the hands of the Chester B. Albree Iron Works Co., Pittsburg, Pa., under the direction of Mr. Chas. R. Cunningham, who is superintendent of the Carnegie Library Building, and a design has been worked out which is of particular interest for its lightness and also for the methods of support and erection that were employed. The requirement was made for its design that its weight be kept down as low as possible owing to the necessity of supporting the structure and mechanism from a rail and guide mounted on the upper portion of the side wall of the building. It was further required that the framework members be kept down to as small sizes as possible in order that the structure should obstruct the light as little as possible when in front of any vertical row of windows of the wing. With all, it was necessary that the framework should be sufficiently rigid to permit of free movement and action of the elevator car and also that it should be so constructed as to permit of adjustment of the alignment of the guide frame structure if this should become necessary.

The traveling structure, as built, consists of a slender box framework, about 80 ft. in height and 3 ft. 2 in. by 4 ft. 5 in. outside measurement in horizontal section, which is so built as to leave an opening or shaft within having an inside clearance of 2 ft. 8 in. by 3 ft. In this shaft there is arranged to travel the elevator cage which has an interior dimension of approximately 30 x 32 in., and provides ample working space for the window cleaner and his outfit of pails. For the convenience of the workmen, the elevator cages were fitted for hand operation by crank and gear mechanisms located in the cages, and to permit of operating the transverse movement of the entire framework carrying the cage, a hand cable operated gear was devised for movement of the traversing gear in the supporting apron at the top, the cable extending the entire length of the framework and permitting such transverse motion to be accomplished from the elevator cage, no matter in what position it may happen to be. These elevator and traversing mechanisms introduced problems of considerable difficulty in view of the particularly light construction which was desirable in the guiding framework and also owing to the desire that the total weight of the apparatus be kept down to as low a limit as possible; the success of the design as adopted is evident from the fact that the entire moving structure including the elevator cages and the gear for both elevating and transverse movements weighs only about 6,000 lb.

The guiding framework consists of four posts of 4 x 2½-in. tees which are framed and braced horizontally by angle stiffening members located at from 7 to 9-ft. intervals on the structure vertically. The latter horizontal angle members were for each tower distributed so as to occur at points opposite the blank wall spaces between rows of windows and thus not interfere with access to the latter. The panels between these horizontal braces are stiffened longitudinally by diagonal ties of ⅜-in. steel rod with turnbuckles for adjustment of the tension. These rods ties occur on the three outer sides of the tower only, being omitted on the side next to the wall of the building for free access to the windows, and also in one of the panels at the base of the tower for entrance to the elevator cage from outside. With reference to the horizontal bracing of the T-posts, it should be stated that it was decided for simplicity to utilize one of the flanges of each of the tees as a guide for the elevator cage, and as a result the construction shown in the horizontal section of the tower was adopted. It consists primarily of 2 x 2 x 3/16-in. angle members between the webs of the tees in direction at right angles to the side of the building which are attached by stiffening gussets of 3/16-in. plates with four rivet fastenings; in these gusset plates are provided also holes in the centers of the webs for the attachment of the diagonal tie rods. The braces in direction parallel to the side walls are 2 x 2 x 3/16-in. angles which are riveted to the outer flanges of the T-posts, over 3/16-in. gusset plates and in addition ¾-in. filler blocks in order to provide clearance for the elevator cage guide clips and these members are, in addition, carried about 6 in. beyond to permit of diagonal struts from their ends back to the side horizontal members; these diagonal struts are 1½ x 1½ x 3/16-in. angles, about 12 in. in length and were necessary for diagonal stiffening of the framework horizontally as no horizontal stiffening construction could be used within the frame. The remaining details consist of two angle members which are erected vertically outside of the framework on one of the shorter sides, for guides to the elevator counterweight; these are 2½ x 2½ x ¼-in. angles which extend the full height of the tower with a clearance of 6 in. between their inwardly projecting flanges and they are supported upon the side horizontal bracing members by brackets formed of sections of 3 x 4-in. angles.

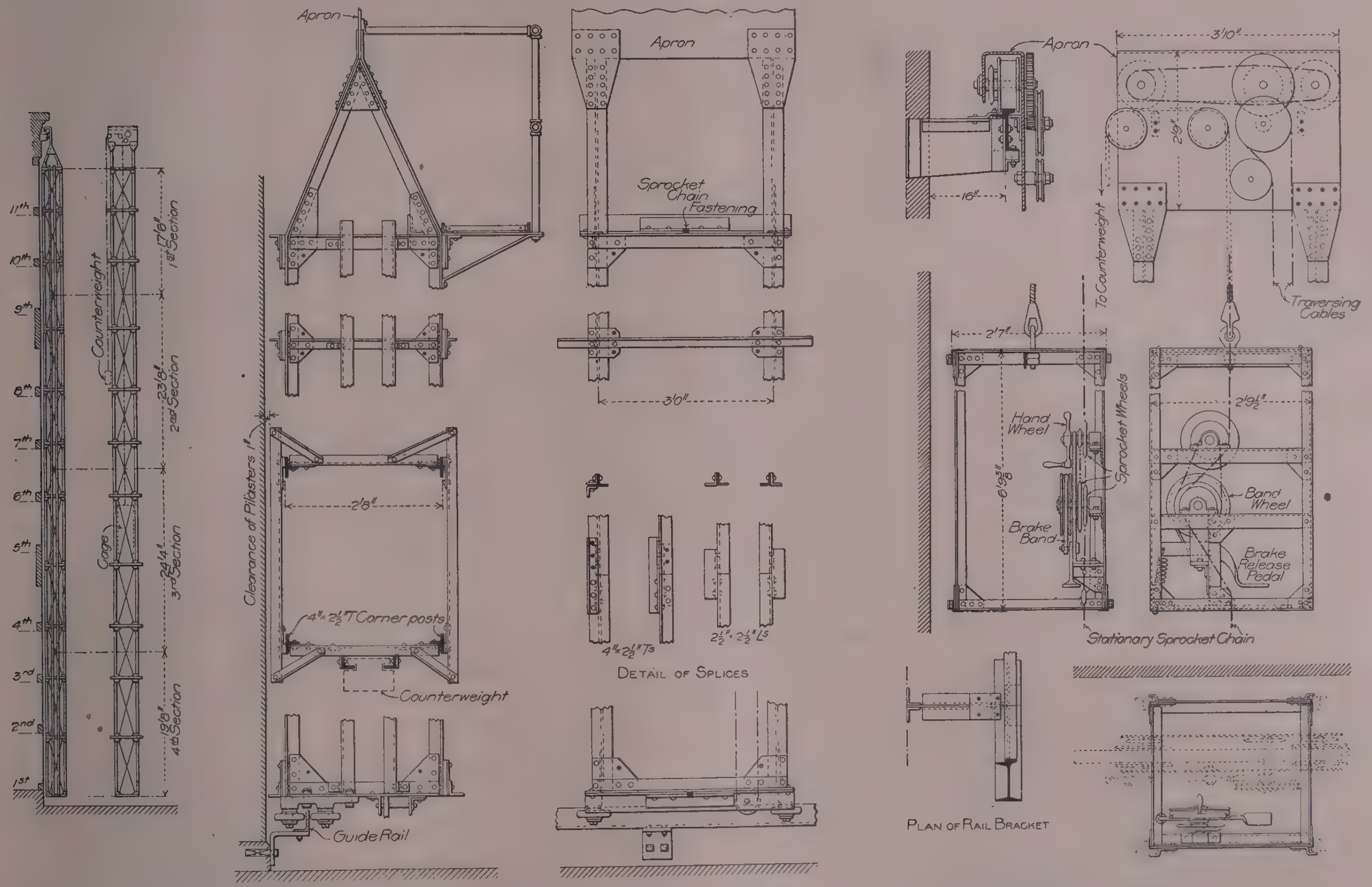
The frame structures are all supported entirely from the top, being fitted with guiding rollers at the base that play on a runway merely for the purpose of preventing side sway. The support construction consists in each case of a special steel-plate apron that is fastened to the top of the framework and carries the runway wheels and driving mechanism that is necessary for the longitudinal movements of the tower frame as a whole. Each apron is a 33 x 46-in. plate of ½-in. steel to which the four corner T-posts are bent in and riveted by special fastenings so applied that the apron is mounted longitudinally over the center of the tower. The special fastening consists of outside cover plates and inside gussets for the tees together with the use of special gusset plates at the top of the rectangular section of the frame where the T-posts bend inward. The apron is bent over at the top and downward at the back so as to form an inverted trough, underneath which are mounted two double-flanged runway wheels upon which the structure is carried. The wheels are of cast steel 10 in. in diameter on the treads and are mounted with roller bearings on 1½-in. steel shafts that project through both the front side and the rear leg of the apron plate, the openings in the plates having bearing seats formed of heavy cast-iron flanges bolted to the outside of the plate. The guide mechanism at the base of the tower consists merely of two 6-in. roller wheels which project downward from special castings on either end of the base of the tower on the inner side and embrace a guide of a 3 x 4 x ⅜-in. angle placed horizontally with the 4-in. flange vertical. This guide angle is mounted upon brackets formed of 6 x ¾-in. plates which are fastened at about 10-ft. intervals to the stone water table of the building at an elevation of about 8 in. above the court pavement. The outer face of the angle is located at such a distance from the wall that together with the location of the upper supporting rail, each tower structure maintains a minimum clearance with the side wall of the wing of 1 in.

The runway tracks upon which the wheels of the apron travel consist of 9-in. flat girder rail of the type commonly used in paved city streets for street car tracks and weighing 110 lb. to the yard, which are supported upon brackets fastened to the wall posts of the building at from 15 to 15½-ft. intervals. The opportunity was taken advantage of before the completion of this wing of the building, to attach the supporting brackets to each of the wall columns at points above the windows and near the cornice, the brackets consisting of ½-in. steel plates about 12 in. deep and projecting from the columns 20 in. or 15 in. beyond the outside wall finish. The plates are fastened to the wall columns by double flanges formed of 3 x 3-in. angles riveted on the inner end and are similarly faced for attachment to the rail by angles of the same size riveted to the outer end. The runway rail was at first erected as a 10-in. 35-lb. channel which was bolted to the upper outer end of the bracket with the flanges projecting outward and the upper edge approximately 2½ in. above the tops of the brackets to provide clearance for the wheel flanges. Upon application of the full weight of the tower and mechanism, however, it was found that the eccentric loading due to the slight overhang of the upper flange caused the channels to bend under the weight, not only in the flange but also between the upper bracket bolts and the flange. As a result the channels were removed and a more suitable rail section was sought for the purpose, a decision finally being made in favor of the ordinary flat girder rail as used in street railway practice. This section, due to the location of the head directly over the web of the rail eliminated the eccentric loading and also the girder flange on the gauge side of the head, permitted the attachment of holding clips to prevent the outward bending tendency as before experienced. These latter clips are of 5½ x ½-in. plates which are riveted to top flanges of the bracket formed of 3 x 3-in. angles and bolted at two points to the rail girder flange. Under the base of the rail there is an additional support consisting of an angle bracket and filler block which are riveted to the outer face of the supporting brackets. With this rail section it has been found that the load is properly located and the section has proven sufficiently stiff that no trouble has been experienced whatever.

The erection of the towers was successfully and quickly accomplished by setting up each tower in four sections of from 16 to 24 ft. at the shops of the construction company and hauling the same on trucks to the library, where they were there hoisted in the order of their completed position by tackle from the runway rail, the lower sections being spliced on as the upper portions were lifted up out of the way. The sections were spliced by means of 2 x 2 x ⅜-in. angles for each of the tee corner posts with four rivets to the web of the tee and six to the flange. The counterweight guide angles were spliced by short sections of angles of the same section riveted back to back. When the upper three sections of the tower frame were spliced, the structure was raised and the runway wheels of the apron hooked over the runway rail, following which it was an easy matter to attach the lower guide section and to carefully align the framework by proper adjustment to the turn-buckle tie rods. The two middle sections of the towers were made approximately 24 ft. in length, while the upper section carrying the apron and traversing mechanism were owing to the weight of the latter made in sections 17½ ft. long. The lower or guide sections were, owing to the different court levels on the opposite sides of the book stack wing, made in different lengths, that in the outer or large court being about 20 ft. long while those for the two inner courts which are from 6 ft. higher in level are about 16 ft. in length. The total elevation from the outer court level up to the runway rail is 91 ft. 10½ in., while similar elevation in the inner courts are 85 ft. 10 in. in either case. The total weight of the longer tower frame structure complete with the elevator cage and mechanisms, is slightly over 6,000 lb.

The traversing mechanism consists of a combination of gearing and sprocket chain driving connections mounted on the apron which are arranged to be operated from any position in the tower by means of a hand rope drive. The double-flange supporting wheels which are, as above stated, mounted within the apron on the 1½-in. shafts with roller bearings, are fitted with

6-in. sprocket wheels which are rigidly bolted to the sides of the wheel castings underneath the rear leg of the apron. These sprockets are both connected by sprocket chain with an 8-in. sprocket between them that is keyed to another 1½-in. shaft which passes through the apron structure near the middle with bushed bearing supports and a gear reduction drive on the outer front face of the apron. This gear reduction has a ratio of 6 to 1 and on the pinion shaft there is keyed a 12-in. rope sheave with a V-shaped groove over which passes the cable for manipulation of the gear from any portion of the tower. The arc of contact of the cable with the sheave is increased by an 8-in. idler sheave which is located underneath the driving sheave that brings the two cables within 4 in. of each other. The position of these ropes and their tension is maintained by an idler sheave mounted at the base of the frame structure and fitted with means for adjustment of the tension. The remaining equipment of the apron consists of two 8-in. sheaves over which the main cable from the elevator cage passes to the counterweight. Access to the apron mechanism for attention and repairs is provided by an 18-in. platform at the top of the tower on the outer side which is surrounded by a pipe railing guard, and the gearings and sheaves on the outer face of the apron are protected from the weather by a sheet steel casing which is made removable for ease of access to the interior.



Details of Tower and Operating Mechanism of the Window Cleaning Traveler, Carnegie Library, Pittsburg.

The elevator cage is a light steel enclosure framed up of 2½ x 2½-in. angles for the corner posts and bottom members and 3 x 3 x 5/16-in. angles for the top members. The top and bottom members are attached to the corner posts with 3/16-in. gusset plates in all cases and longitudinally across the top of the cage there is riveted in a 3 x 3 x 5/16-in. angle, to which the counterweight cable fastening is made. At each corner of the cage on top and bottom there are fastened guide clips so arranged as to project over and enclose the free flanges of the tee corner posts of the tower structure for guiding the car in its travel. Considerable clearance is allowed at each of the guide points to permit of free movement of the cage in case the tower structure is out of alignment. The cage is suspended by a steel cable which passes over the two 8-in. single groove rope sheaves on the apron at the top and down on the outer side of the tower to the counterweight, the cable being a ⅝-in. flexible wire rope. The counterweight is adjusted for an overbalance of the empty cage of about 100 lb. in order to partially compensate for the load of a cleaner and his paraphernalia, and thus render the car movement in vertical travel somewhat less difficult, and in order to allow for unequal balance of the counterweight cable as when the cage is at its upper or lower extremes of travel, a compensating chain is suspended between the bottom of the cage and the tower structure at mid-point of the car travel. An ordinary ¼-in. iron chain of length sufficient to reach to the base of the cage at either top or bottom extreme of travel, was found to amply compensate the variations in balance due to the position of the counterweight cable. The cage weighs with operating mechanism about 500 lb.

The mechanism that was provided for the operation of the car in vertical travel is of interest in that it was the desire that the cage should be capable of being moved by the man within it and always under such control that it could be stopped and held firmly at any point in its travel. It was at first attempted to locate the operating mechanism on the apron at the top of the tower with control of the same through hand ropes from the cage as in the case of the longitudinal travel of the structure, but the satisfactory operation of the holding brake in such a case involved such difficulties that it was decided to install a mechanism as compact as possible within the cage itself, for this purpose. It was thought desirable to operate the car independent of the supporting cable or attachments, and in the place of using a rigid rack mounted within the tower for the purpose of securing a positive movement of the cage, an ordinary sprocket chain was suspended within the tower, passing through the outer side of the cage, which is arranged to engage with sprocket wheels of the operating mechanism so that the movement of the hand wheel will raise and lower the cage. This chain is an ordinary 1-in. detachable sprocket chain and is fastened rigidly within the tower, being anchored to the apron at the top and having an adjustable attachment to the base of the structure for the purpose of taking up slack. Within the cage it passes over two idler sprockets and a driving sprocket, the latter being offset from the center line of the tower, as illustrated in the driving mechanism drawing, in order to insure proper mesh with the teeth of the sprockets. On the shaft carrying the upper idler sprocket, there is also located a loose hand wheel carrying a small auxiliary chain sprocket from which a local driving sprocket chain passes to a large chain sprocket keyed to the shaft that carries the driving sprocket meshing with the stationary vertical chain. The proportions of these chain sprockets of the driving mechanism are such as to give a gearing ratio of about 10:1, thus rendering the operation of the cage comparatively easy. The holding of the car in any position is accomplished by a brake operating on a band wheel also keyed to the shaft carrying the main driving sprocket, which brake is actuated by a spring retained lever that normally holds the brake applied and is released only by holding the foot on a brake treadle so placed as to counteract the tension of the spring. The brake lever is pivoted together with the stationary end of the brake band, directly under the main driving sprocket; the free end of the band being attached to the lever at a point midway between the pivot and the spring attachment. The spring used is one of about 200 lb. tension, and with the leverage afforded by the position of the attachment, is found of sufficient power to hold the car securely at any point in its travel with the load of a cleaner and his paraphernalia.

Location Methods on the Natal-Cape Railway, South Africa.

The Natal-Cape Ry. is the Natal portion of a proposed intercolonial railway designed to give direct communication between Cape Colony and Natal. It was at first intended to serve an imperial purpose at a time when the only railway connecting these two British colonies lay through the South African Republic and the Orange Free State. While the preliminary negotiations and surveys were proceeding the Boer War broke out, and the subsequent annexation of the two independent states removed one argument in favor of a Natal-Cape Ry. It was never proposed, however, that the scheme should be abandoned on that account, as a railway through the native territories lying between the Great Kei River in Cape Colony and the Umkomaas River in Natal is much needed, both for purposes of administration and for trade. Therefore, in spite of engineering and financial difficulties, the agreement entered into by the two colonies 10 years ago continues in process of fulfilment, and Natal has, at a cost of about $4,210,000, constructed 95 miles of railway through a semi-mountainous country and has pushed the rail-head to within 13 miles of Riverside, the agreed point of junction on the Natal-Griqualand border.

A description of the principal topographical features of the country between Pietermaritzburg and Riverside, and of the methods adopted in the final survey and setting out of the line, were described by Mr. David Wilson in a paper printed in the Minutes of the Proceedings of the Institution of Civil Engineers, from which these notes are taken.

The Natal-Cape Ry. joins the main line of the Natal Government Railways at Pietermaritzburg, the distance to Riverside being about 108 miles. The route crosses the valley of the Umkomaas River, a barrier that cuts off the southern portion of Natal from easy communication with the rest of the colony. The extensive development has been necessary, in order to obtain the fairly easy maximum gradient of 1 in 40. The greatest rise lies between the Umsindusi River at mile 2, which is at an elevation of 2,106 ft., and Elandskop Station, mile 37, which is at an elevation of 4,587 ft. The greater part of the route lies along steep hillsides, intersected by gorges and running out into spurs, most of which had to be banked across or cut through at the expense of very heavy earthworks. The deepest cutting is more than 70 ft. in depth, and some of the embankments are more than 50 ft. in height. Sidelong slopes of 30 deg. are not uncommon, and at several places the formation has been cut out of the face of krantzes. The main valleys and spurs have been negotiated by curves having a minimum radius of 400 ft., with the exception of a group of three curves of 300 ft. radius. Many of these are horse-shoe loops running up to 266 deg. of curvature and one-half mile in length.

In such a country very careful location is necessary if waste of money on earthworks is to be avoided. Care was especially called for when, as generally happened, these long curves on steep ground were laid out on the maximum gradient, and no balancing of earthworks was possible after the section had been plotted. Moreover, in order to follow as nearly as possible the contour of the ground and to avoid frequent and sudden changes of curvature, compound curves had to be introduced.

The setting out of these long compound curves was one of the main features of interest in the work, and the methods employed will be explained by following in detail the location and setting out of the loops at the upper crossing of the Sizananjan. Advantage was taken of the fan-shaped widening out of the valley at the source of the Sizananjan spruit to double back against the contours and thus to gain M'Cejas Nek without introducing reversing stations. The length of this loop is 3,250 ft. The vertical height gained in that distance by a continuous compensated gradient of 1 in 40 is 66.5 ft. The horizontal distance between the ends is only 135 ft.

The compound curve forming the crown of the loop was located and set out in the following manner: The contour plan had been already prepared from cross-sections taken from traverse lines. On this plan, by the process of plotting trial sections, the line which seemed to be the best in respect of both economy of construction and easy changes of curvature was laid down. The lengths *B J*, *J K*, *K L* and *L C*, Fig. 1, components of the compound curve thus decided on, were carefully scaled from the plan, and the angles of curvature corresponding with these lengths were worked out. In the field the main tangents *A G* and *A D* were set out by offsets from the traverse lines, and the angle *B A P* was observed; as the sum of the angles of curvatures should be equal to 360° — *B A P*, one or more of these as found from the plan were altered slightly to make their sum equal to the observed angle. The functions of the component curves were then worked out for the angles thus corrected. All the angles of the polygon *A D E F G* and the lengths *B D*, *D E*, *E F*, *F G* and *G C* being thus known, there only remained to be determined the lengths *A B* and *A C*, in order to fix the position of the ends and set out the compound curve touching *A B* and *A C*. To determine the lengths *A B* and *A C* it is necessary first to solve the triangles *D E I* and *F G H*. The length *H I* will then be known, and hence the triangle *H I A* can be solved, and the lengths *A B* and *A C* found by subtracting the known lengths *B I* and *C H* from the lengths *A I* and *A H*, respectively. The points *A* and *B* having been fixed by chaining from *A*, the intersections *D*, *E*, *F* and *G* were fixed by a traverse and the subsidiary curves were set out in the usual manner. The curve *L C*, although shown as a symmetrical compound curve, has been treated as a simple curve. The method of doing this will be explained later.

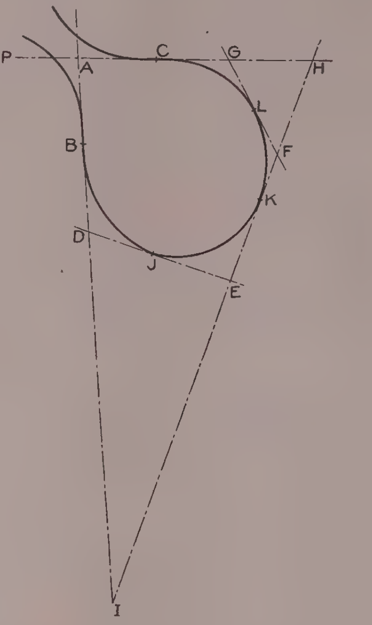


FIG. 1

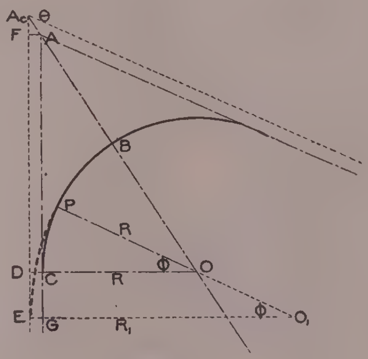


FIG. 2

The only extra work here involved has been the solution of three triangles, causing no appreciable delay in the field work. It will thus be seen that a curve of at least four different radii can be set out with ease by this method. Abrupt and unnecessary changes of curvature are avoided, and the contour of the ground is followed as closely as the limiting curvature will permit. Compound curves were also introduced to flatten the ends of sharp curves and thus to act as transition curves. The maximum curvature was 14.3 deg. per 100 ft., and instructions were issued by the superintending engineer of surveys and construction that at least 100-ft. length of a 10-deg. or flatter curve was to be inserted at the ends of all curves sharper than 11.5 deg. The following is the method adopted of calculating the tangents of these symmetrical compound curves.

B P C, Fig. 2, is one-half of the simple curve. *P C* is to be replaced by the flatter arc *P E* and symmetrically at the other end. Given $A C = T$, the tangent of the simple curve, it is required to find $A_c E$, the tangent T_c of the compound curve.

$$T_c - T = D E + A_c F,$$

but $D E = O O_1 \sin\phi = R_1 - R \sin\phi,$

$$\text{and}\quad A_c F = A F \tan\frac{\theta}{2} = E G \tan\frac{\theta}{2}$$

$$= R_1 - \left\{ R + (R_1 - R)\cos\phi \right\} \frac{\sin\frac{\theta}{2}}{\cos\frac{\theta}{2}}$$

$$= (R_1 - R)(1 - \cos\phi)\frac{\sin\frac{\theta}{2}}{\cos\frac{\theta}{2}}$$

Therefore

$$T_c - T = (R_1 - R)\left\{ \frac{(1 - \cos\phi)\sin\frac{\theta}{2} + \cos\frac{\theta}{2}\sin\phi}{\cos\frac{\theta}{2}} \right\}$$

$$= R_1 - R \left\{ \frac{\sin\frac{\theta}{2} - \sin\left(\frac{\theta}{2} - \phi\right)}{\cos\frac{\theta}{2}} \right\}$$

$$= 2\,(R_1 - R)\sin\frac{\phi}{2}\left(\frac{\cos\frac{\theta - \phi}{2}}{\cos\frac{\theta}{2}} \right)$$

This is a general expression for the increase in length of the tangent, due to inserting an arc ϕ of radius R_1 at each end of a curve of radius R and angle θ. The coefficient $2\,(R_1 - R)\sin(\phi/2)$ can be worked out and tabulated for the cases required in practice, so that all that remains to be done in the field is to work out the ratio $\cos\frac{\theta - \phi}{2} \div \cos\frac{\theta}{2}$ and multiply it by the constant taken from the prepared table and add the product to the length of the simple tangent. In the only case of common occurrence on the Natal-Cape Ry., viz., inserting 100 ft. of 10-deg. curve at the ends of a 14.3-deg. curve, this constant is exactly 30. As the ratio

$$\cos\frac{\theta - \phi}{2} \div \cos\frac{\theta}{2}$$

is greater than unity the process gave a lengthening of the tangents, and consequently of the curve at each end, of at least 30 ft., and seems to afford a good practical transition curve.

The distance to which it would be necessary to displace the tangent, in order to leave the crown of the curve in the same position, is

$$(R_1 - R) - (R_1 - R)\cos\phi = (R_1 - R)(1 - \cos\phi),$$

a quantity depending only on the radii of the curves and the length of the transition curve, and which can therefore also be tabulated if found desirable.

The gauge of the Natal-Cape Ry. is the standard South African gauge of 3 ft. 6 in. The maximum gradient is 1 in 40 on the straight, compensated on curves by 0.04 per cent. per degree of curvature. The choice of gradients lay between 1 in 40 and 1 in 30. The route at its worst places does not admit of an easier ruling gradient than the former, and there was no reason for suggesting a steeper gradient than the latter. Where sections of an easier gradient were possible they were introduced. Where short reverse gradients occurred on a falling section special care was taken to make them as easy as possible. Thus, from Elandskop to Maritzburg the ruling gradient is 1 in 70, and to Umkomaas 1 in 60. Similarly from Binghams Nek to Umkomaas is 1 in 60, and to Umzimkulu 1 in 50. In some places great difficulty was experienced in obtaining a gradient of 1 in 40. This applies particularly to the section between Taylors Station and Elands River, a length of 25 miles, where a 1 in 30 gradient would have shortened the route considerably. On the other hand, between Umkomaas and Binghams Nek, a length of 20 miles, in spite of the apparently artificial development that has been resorted to, the adoption of a 1 in 30 gradient would not have made any appreciable difference in the length. On one part of this section, namely, Sizananjan Station to M'Cejas Nek, a length of 5 miles and a horizontal distance of about 1 mile, with a rise of 570 ft., there is a loss of only 6 ft. from the maximum gradient. Lowering of the level at the summit by one foot would have increased the cutting there by 600 cu. yd. of hard shale, and raising it by one foot would have added similarly to the cost of the bank at Sizananjan Loop, half-way up. The adoption of a gradient of 1 in 30 between these points would have given a line covering practically the same ground, although a little might have been saved in the earthworks by breaking up the gradients and fitting the ground more closely.

With regard to curves, the choice of a limit radius lay between 300 ft. and 400 ft. Evidently in such a country the use of the smaller radius would have reduced the work considerably. On the other hand, the adoption of a limit curve appreciably flatter than 400-ft. radius would have necessitated abandoning the route altogether. It will thus be seen that the gradients and curves which have been adopted are the best that the route admits of. The policy of making a better line than is necessary for present requirements was directed by the consideration that the Natal-Cape Ry. is part of an intercolonial railway which may be reasonably expected to become an important route when the through connection has been made and the resources of the country have been developed. This railway is now open for traffic to Creighton Station, a distance of 95 miles; the work of construction beyond that place has not yet been commenced. The magnitude of the work already done may be gauged from the fact that more than 2,700,000 cu. yd. of earthworks have been paid for. The cost of transport of materials was a heavy item, and the need of a railway to develop the country is shown by the fact that the contract price for transporting a cask of cement by ox wagon to Binghams Nek, before the first section was available for rail transport, was about $3.50.

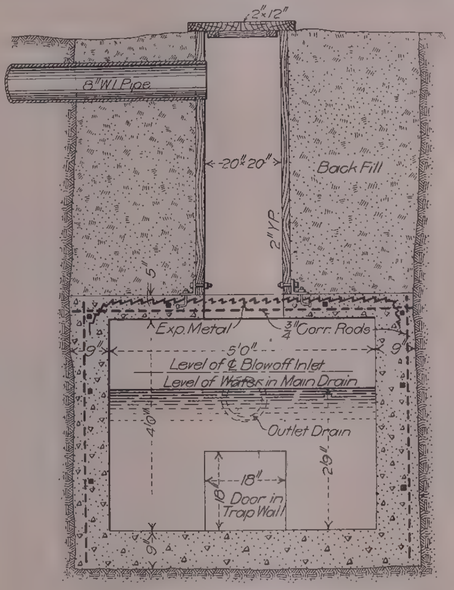
Coal Production in France is shown by recent statistics to be only one-fifth of that of Germany, one-seventh of that of Great Britain, and less than one-tenth of the production of the United States. The production for 1904 was reported as 34,168,000 tons, an increase of only 1,800,000 tons above the total of 1898, six years previous.

Some Notes on the Boiler Blow-off.

By Warren H. Miller.

Judged from an extensive acquaintance with many industrial establishments the most neglected part of the power-plant design has been the disposal of the boiler blow-off. It is the weakest link in the chain of processes by which the power that drives the tools all over the various shops is produced from the coal pile. Time and again the writer has run across cracked and leaky sewers, into which the boiler blow had been turned, and one enterprising designer even attempted to trap the blow in a small sump and vent off the steam through a convenient leader pipe with the result of showering the hot water all over his own and his neighbor's roofs.

Many of our designers, especially those of little practical experience, do not realize that this innocent-looking, muddy boiler water is to all intents and purposes steam, live steam and worse. The instant the boiler water passes the blow-off cock and all pressure is released, a large part of it flashes into steam of some ten times the volume of the original water. This process is virtually instantaneous, so that, unless the blow-off drain is very short, pressure is immediately raised, and in the ordinary 6 or 8-in. drain some 20 to 30 lb. pressure develops, notwithstanding the fact that the mouth of the drain is open. The steam generates so fast that it is impossible to hurry along the column of water ahead of it in the drain fast enough to prevent pressure accumulating at the blow-off cock. For this reason the boiler blow-off drain should never be tile nor light cast-iron soil pipe, except in very short, straight leads, but should be piped throughout with wrought-iron pipe and screwed pipe fittings just as if live steam were to be handled.



Section of Blow-off Pit.

Let us assume that the problem reaches an acute stage in the large industrial establishment comprising anywhere from ten to thirty buildings. Here there is no convenient field or ditch to turn the boiler blow into, and it must run into one of the main drains. These are usually 12 or 18-in. vitrified tile drains put down to stay. It will not do to blow directly into them, even though they may be partly filled with flowing water. The hot steam and the pressure combined will crack the expensive main drain everywhere in the neighborhood of the junction and upset processes all over the works.

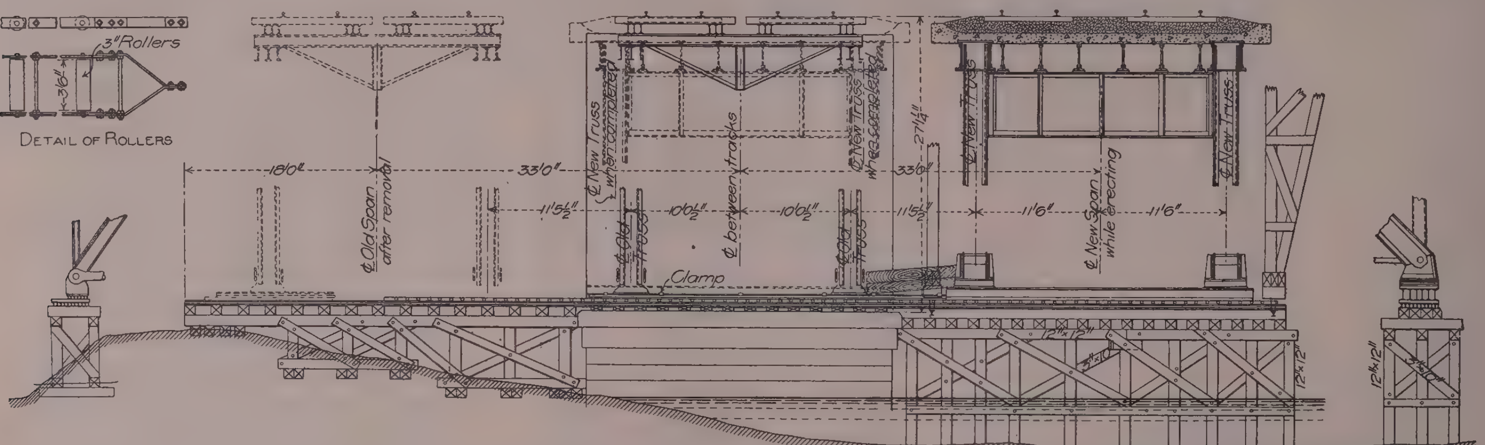
Here is a concrete case. In a certain large chemical works in New Jersey the main process drain is 18 in. in diameter and passes the power house at a distance of some 70 ft. From the back of the battery of four 200-h.-p. boilers the blow-off drain led into the engine room, down the length of the engine room and out to the main drain, which it joined at right angles. The boiler blow connections, of which there were eight, consisted each of a 2½-in. Cadman valve shutting against the boiler pressure; between this and the boiler was an iron asbestos-packed straightway cock; 45-deg. ells connected each blow into the 4-in. wrought-iron main by a 2½ x 4-in. Y junction. The main was pitched 1 ft. in 40 ft. to prevent the accumulation of water and led into the engine room. Here it joined the engine-room drip-and-waste-water drain, a 6-in. cast-iron soil pipe.

The question then arose, how close could vitrified drain tile be trusted? It was decided to run the soil pipe 40 ft. further in 8-in. size and then change to vitrified tile, the depth of the drain being 7 ft. below grade, to meet the main drain. This was done, but in less than a month the drain choked up and on digging it up the entire length of vitrified clay pipe, about 35 ft., was found to be cracked by the blow-off pressure and caved in by the weight of the earth above. The cast-iron soil pipe was intact. A boiler was then blown down with valve full open to observe the state of the boiler water upon delivering from the cast-iron pipe. It was found to shoot out mixed water and steam at a pressure of not less than 15 lb., enough to easily burst the vitrified tile. And this all came from a 2½-in. cock discharging hot boiler water over 200 ft. away. There was plenty of life in the steam and it seemed hopeless to run it into the main drain at that pressure. It would only be a question of time before that, too, would break and cave in and stop the whole works.

The writer's solution was as follows: It is first necessary to arrest the water in a trap sump, vent off the steam and cool the water to somewhere about 170° Fahr. before allowing it to pass on to the main drain. Blowing down 3 in. or half a gauge of the two 18 x 3-ft. drums of a tubular boiler means taking care of 30 cu. ft. of water at about 352° and 125 lb. boiler pressure. The instant this passes the blow-off cock its pressure is reduced to about 20 lb., the pressure of the velocity of outflow and sufficient water boils into steam to reduce the temperature of the whole to 260°. To find out how much steam is evaporated we subtract 260° from 352°, giving 92°, and multiply by 1975 lb., the weight of 30 cu. ft. of water. This gives us 181,000 B.t.u., which we then divide by 1161, the latent heat of steam at 26 lb. pressure. By this division we get 156 lb. as the amount of water which boiled into steam at 20 lb. pressure as soon as the hot water passed the blow-off valve. This steam takes 11.66 cu. ft. of space per pound, so 156 lb. of it would be 1820 cu. ft. of steam to be taken care of by the vent of the sump. But when the mixed hot water and steam are discharged into the sump the pressure falls to nearly atmosphere and enough more water boils into steam to even things up and reduce the water to 212°, its proper temperature at atmosphere. This amounts to 90 lb. more steam and leaves 1730 lb. of the original blow-off water still to be cooled down by the sump, the rest going out of the vent as steam. Let us say we can place the sump as shown in the sketch so that it will always be half full of back water from the drain. Taking this water at 75°, the mixture of this and the blow-off water should come out about 180°. The total heat in the blow-off water is $1730 \times 212° = 366{,}760$ B.t.u. Let w be the weight of the water to be mixed in at 75°. The total heat of this will be $75\,w$ and the heat of the mixture will be $75\,w + 366{,}760$. This is equal, of course, to $(1730 + w)$ 180° and gives 80 cu. ft. as the needful amount of water in the sump. Allowing as much more for steam space, a sump, 4 x 5 x 10 ft. long, inside dimensions, will answer the purpose.

The design shown was made and a rectangular pit dug in the drain trench 6 ft. 6 in. wide, 3 ft.

deeper than the discharge pipe and 13 ft. long. Then 9 in. of rock concrete was laid for the bottom of the sump and ¾-in. corrugated reinforcing rods spaced 3-ft. centers were set in at the sides. As soon as the slab hardened two longitudinal rods were tied in all around the sump, as shown, and the carpenters put to work on the box to form the inside wall surfaces, it being 9 in. from the earth walls of the pit. This space was then filled all around with 1:3:5 rock concrete and 3-in. expanded metal sheets put in place across the tops of the centering to form a ceiling reinforcement for the sump. After two days' set, the forms were pulled and the carpenter work done on the trap wall and ceiling. The ceiling was then poured, a slab 5 in. thick reinforced with ¾-in. corrugated rods in addition to the expanded metal, for it would have an earth pressure of 900 lb. per square foot upon it besides a more or less unknown steam pressure from within. When the roof concrete was still wet the wooden vent was set in place and its bolts allowed to set in the concrete. The idea of having the manhole and vent in one was to give a sort of safety outlet by way of the cover of the manhole in case the pressure of steam in the sump became very great. Some old 8-in. pipe was let into the side of the vent and led off under a pipe trestle where the blow could do no harm.



Elevation of Abutment and Track for Replacing a Double-Track Steel Span.

After the sump had hardened for ten days the ceiling and bridge wall forms were struck and passed out in pieces at the manhole. Then the stop was taken out of the tile lead to the main sewer and the sump promptly filled to the drain level, closing the trap to steam and furnishing the cold water to cool the blow-off.

A boiler blow was then opened wide and half a gauge blown down. The discharge pipe showered mixed steam and water clear back to the trap wall and steam shot out of the 8-in. vent pipe some 15 ft. There was sufficient pressure in the sump to cause the manhole cover some uncertainty as to whether to stay on or not, but an empty barrel set on it proved decisive.

On examining the junction into the main drain hot water was found to be flowing through at about a foot per second, but no steam got past the trap. The sump would take care of four 200-h.-p. boilers before it got too hot to run the water into the drain.

Let me close this article with a few "Don'ts." Don't let them inveigle you into depending upon a blow-off valve alone. It is sure to leak; not much, but enough to make lots of trouble in case you want to connect in to the blow-off drain anywhere. Put on an iron asbestos-packed cock in front of the valve. Brass plugs are too soft for this service and the usual screw-fastened plug only gives two more live joints to leak and annoy.

Don't connect any leaders or downspouts or catch-basin drains into the blow-off drain anywhere. The temptation is great, especially hundreds of feet from the boilers, but you will be smothered with steam from them just as certainly as you will blow down the boilers at the noon whistle.

Don't connect the economizer blow-off into the boiler blow. Most of the blow from the economizer comes along the wall boxes direct from the inlet valve, so you are putting ordinary warm feed-water into your blow-off drain. The minute this strikes the loose steam that is always dripping more or less from the blow-off cocks, you have earthquakes and water hammers of astonishing magnitude.

Don't fail to put a back check on all engine and feed-pump drips into the blow-off drain. Remember that the pressure developed in blowing off is anywhere from 20 to 70 lb. and if any drips are open it will back up into the engines and cause contingencies too numerous to mention.

Don't put the grease-extractor drip into the boiler blow-off drain. This drip must stay open or else the extractor fills up and greasy water gets over into the feed-water heater. The boiler blow comes along, finds this way open to liberty through the grease extractor and you get a shower of squish into the exhaust.

In a word, treat the blow-off drain as a live-steam line, taking the same care to avoid water pockets, pitching it always in the direction of the flow.

Below is a table of the actual costs of the blow-off sump described:

Cost of Blow-off Sump.

Excavation (11 ft. from surface to sump bottom)	$34.25
Tile and placing (8-in. vitrified, 15 lengths)	11.25
Carpenter work	17.69
Plank forms (1-in. hemlock, dressed one side)	5.36
Reinforcement (¾-in. corrugated bars, 3-in. No. 10 mesh expanded metal)	12.61
Concrete labor, mixing and placing	26.23
Sand	3.05
Cement, 33.6 cts. per bag	8.06
Rock, 7¼ cu. yds. at 85 cts	6.16
Total	$124.66

The excavation charge included a trench 25 ft. long from the sump to the main drain. The drain tile charge was also high because a small brick junction box was built at the connection of the sump drain with the main process drain. This was provided with a cast-iron cover and the flow and temperature of water, running out of the sump at blowing down, could thus be observed.

A Large Tower Crane carrying a jib of 53 ft. radius 93 ft. above the ground has been erected in the Bremer Vulkan Shipbuilding yard at Vegesack, Germany. The tower has a rectangular cross section and runs on rails of 20 ft. gauge. The distance between the trucks under the tower legs on each side is 26½ ft. The jib crane is carried near the top of the tower by guys running from the top. The crane has a lifting capacity of 3 tons at a radius of 53 ft. or 6 tons at a radius of 30 ft.

Quick Replacing of a Double-Track Steel Span.

The main line of the Philadelphia division of the Baltimore & Ohio R. R. was formerly carried across Red Clay Creek at an elevation of about 25 feet above the water by a double track, pin-connected Pratt truss span of about 166 ft. clear opening.

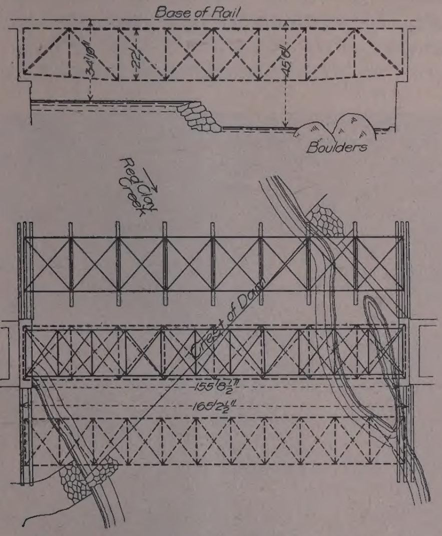
The bridge was square with its abutment, but on a considerable skew with the river and its axis made an angle of about 45 deg. with the crest of a rubble dam about 10 ft. high, which intersected it near the center point. The lower chord was about 10 ft. in clear height above the crest of the dam. The old span had trussed floor-beams resting on the top chord and supporting four lines of stringers, each compsoed of three I-beams, the outer lines being nearly over the centers of the trusses.

It was replaced last July by a new pin-connected Pratt truss span 160 ft. 10 in. long, 22 ft. deep and 23 ft. wide on centers, designed in accordance with the Baltimore & Ohio Railroad Company's specifications of 1904 for a live load of two E50 locomotives and a train load of 5,000 lb. per lineal foot. Six lines of plate girder stringers are seated on the floor beams with their top flanges flush with the top chords, and with the latter support a reinforced concrete platform, 31 ft. wide and 8 in. thick, except at the outer edges, where the thickness is increased to about 8 in., forming a sort of flange to retain the ballast in which the ties are laid as on the ground. The construction is somewhat peculiar in that at each abutment the shoes are seated on a group of seven transverse 12-in. 40-lb. I-beams 28 ft. long, bolted together with separators and forming a single grillage on the masonry.

As it was required to replace the old superstructure without any interruption to the heavy traffic, it was decided to erect the new superstructure on the old substructure by transverse displacement. The new span was accordingly erected parallel to the old span and about 4 ft. distant from it upstream in the clear. It was erected at exactly the required height on ordinary falsework bents seated on the dam and on the rocky river bottom. The end bents in line with the abutment were made triple with 12 x 12-in. square vertical posts driven into the ground like piles and X-braced both transversely and longitudinally to form long narrow towers.

The falsework caps, parallel to the bridge axis, supported a solid platform made by four 12 x 12-in. transverse timbers laid close together, carrying a set of 11 parallel continuous 85-lb. rails set close together, 3-in. steel rollers parallel to the bridge axis were set about 1 ft. apart on the rails and on them were seated the 12-in. I-beam grillages carrying the truss shoes. The downstream ends of the abutments were extended in like manner by double falsework bents about 36 ft. long with continuous 12 x 12-in. caps transverse to the bridge axis, which carried 12 x 12-in. cross ties 5 ft. long and 30 in. apart on centers supporting a set of 11 roller track rails corresponding to those under the new span.

After the new span was completedly erected, and the track laid on it, the feet of the vertical end posts were connected with struts and ties to those of the adjacent truss of the old span. The old span was jacked up 12½ in., the 3-in. cast-iron masonry bed plates were removed, and a tier of 11 rails were set underneath the shoes connecting with those on the up and down stream falsework and supported on 2 x 12-in. oak blocks 2 ft. apart on centers laid on top of the abutment masonry. These rails received a set of solid steel rollers like those under the new span, and on them was placed a second tier of 11 rails, spliced to those forming the upper roller track on which the shoes of the old trusses were lowered to bearing. The rails in the upper or live track were fastened together by five transverse horizontal clamps one on each side of each shoe and one in the middle. Tackles were attached to the feet of the vertical end posts in the down-stream truss and their lead lines were taken to the drums of hoisting engines seated further down stream.



Erection by Transverse Displacement.

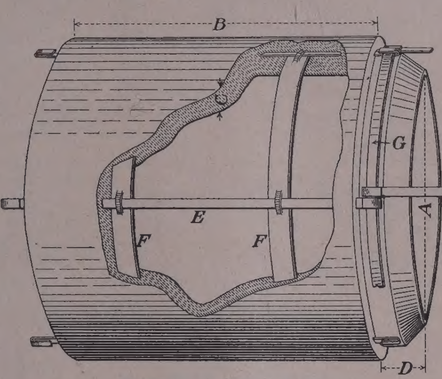
The last trains passed over the west bound and eastbound tracks at 11:05 and 11:11 A. M., July 17th, respectively, after which the tracks were immediately cut and all was in readiness for shifting the bridges at 11:14 A. M. Pulling was commenced at 11:17 and, after both spans had been moved 8 ft., was stopped at 11:19 and a delay of 8 min. was taken to enable the engines to recover steam. Pulling was resumed at 11:27 and at 11:31 was again stopped, both spans, weighing together about 1,000 tons, having been pulled 33 ft., leaving the new span in its required exact permanent location and the old span clear of it on the down-stream falsework, whence it was afterwards removed at leisure. It is thus seen that the structure was out of service only 36 min. The white oak blocks supporting the first tier of rails on the abutments were replaced by steel bars, and another tier of steel bars was placed between the track rails and the 12-in. I-beam grillage under the new span in the spaces between the solid steel rollers. All spaces between the I-beams, rails, rollers and masonry were grouted and the rollers were left permanently in position, forming with the I-beams a permanent distributing grillage enclosed in concrete on top of the abutment masonry.

The work was designed and executed under the direction of the Engineering Department of the Baltimore & Ohio R. R., Mr. J. E. Greiner, chief engineer, and Mr. Wm. Graham, assistant engineer.

Reinforced Concrete Sewers in Wilmington, Delaware.

The congested condition of one of the intercepting sewers in Wilmington, Del., has been overcome by the construction of the relief sewer about 3,200 ft. long. When the plans for this sewer were prepared the conclusion was made to manufacture pipe for it according to the patents of the Reinforced Concrete Pipe Co., of Jackson, Mich. The pipe was finished for the entire length of the sewer before any excavation was started, each length being cast and stored on the surface near the position it was to occupy in the trench, thus entirely avoiding any hauling of the finished pipe. Mr. Alex J. Taylor, engineer in charge of sewers in Wilmington, has furnished information to this journal regarding the methods of casting and laying the pipe and the details of the cost of the part of this work, and from this information the following notes have been prepared.

The dimensions of the various parts of the pipe, and the spacing and sizes of the reinforcement are as given in Table 1, in which the letters refer to those shown in the accompanying illustration. The pipe was made in two sizes, 30 and 36 in. in diameter. The reinforcement, as indicated in the drawing, is composed of two circumferential bands, spaced 1 ft. apart and 1 ft. from each end of the pipe. These bands are slotted to allow five longitudinal reinforcement bars to be threaded through them. The longitudinal bars extend beyond the shoulders of the pipe and are hooked at the ends to provide for interlocking the various sections after the latter are placed.



Details of Pipe Section.

The forms in which each section of the pipe is cast consist of a cast-iron bottom ring, a cast-iron collar for the spigot end and two concentric steel cylinders rolled to true circles. The inner cylinder is in three, and the outer one in two sections, the sections being joined when in place by iron latches that permit them to be set and removed readily.

Table 1, Dimensions and Details of Pipe.

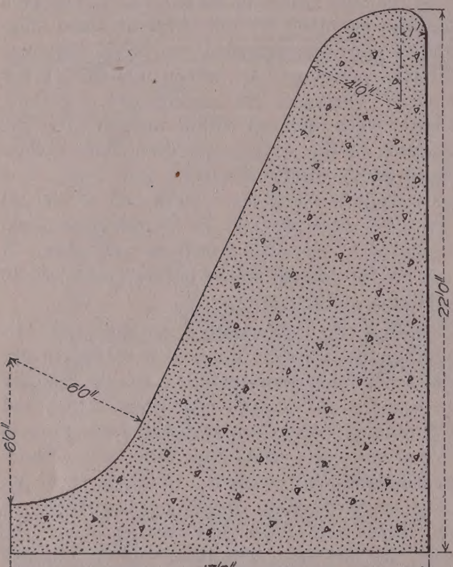
Dimensions of Pipe.				Size of Reinforcement.		
A—Diam., in.	*B*—Length, ft.	*C*—Thickness of wall, in.	*D*—Length of flange, in.	*E*—Bars, in.	*F*—Bands, in.	*G*—Tie bands,
30	3	3½	3¾	⅛x⅝	⅛x1½	⅛x⅝
36	3	4	4⅛	¼x½	⅛x1½	⅛x¾

The pipe is cast upright, with the bell end down. The bottom ring is first placed in a position convenient to the platform on which the concrete is mixed by hand, and to the trench before it is leveled up and greased; the wall forms, previously oiled, are next slipped into the place and latched, sliding on grooves in the bottom ring. The longitudinal reinforcing bars are then set in position, their lower hooked ends entering into depressions made in the bottom ring to receive them. At the upper end these bars are caught and held in position by clamps, which serve in addition to space the two concentric cylinders and make the walls of the section the proper thickness. A circular stiffening band is then slipped inside and hung on the upper end of the inner cylinder to prevent the distortion of the latter while concreting is in progress. When the molds are set up and braced, as described, each is an exact duplicate of the others, so the finished sections must fit when joined together. The concrete must be shoveled into the molds, no dumping being possible, and care has to be exercised that the unrammed concrete is not deposited in layers exceeding 3 in. in depth. Any deviation from this method can be detected by the porosity of such places when the forms are stripped the next day. Special tamping tools, curved in plan and slotted at the ends, are used to permit the concrete to be rammed well around the bars. When one foot of concrete has been deposited and rammed the clamps on the longitudinal bars are removed temporarily, a band slipped over them, the clamps replaced and concreting resumed. After another foot in height is reached this operation is repeated. Then, when the upper end of the pipe is reached a cast-iron collar having a section that will mold a spigot end, as shown in the drawing, is placed in position; the back of the collar being formed by the inner cylinder of the form, which cylinder extends beyond the outer one for this purpose. Concrete is filled in this collar and smoothed with a small trowel, finishing the section of the pipe. Since in the work at Wilmington five times as many bottom rings as there were cylinders had been provided, the newly cast pipe sections were allowed to remain undisturbed for five days. Owing to the scarcity of the collars, the latter were removed within an hour after the completion of the section, and the cylinders were stripped a day after the casting was done. The pipes were kept moist for a week and at the end of five days were upset so the bottom rings could be removed. The various sections were then left to season for several weeks before being laid in the trench.

Regarding the manufacture of the pipe, Mr. Taylor says the amount produced in this particular work is not fairly representative, for the molding was hampered by a lack of sufficient forms, and had additional forms been available, from 30 to 40 per cent. more pipe could have been built without increasing the labor account. In all, 60 ft. of 30-in. and 57 ft. of 36-in. forms were provided, so when these were filled pipe casting had to be stopped for the day. The labor and cost figures obtained during the making of 1,506 ft. of 36-in. and 1,275 ft. of 30-in. pipe are as follows: The labor account includes unloading and moving the cement and forms a distance of 600 ft. from the cars; oiling, setting up and slipping the forms, concreting and, in fact, every feature essential to the production of complete pipe. Common labor was rated at $1.50 for 8 hr. and a foreman at $3.50 per day. The total labor cost under these conditions was $1,033. The concrete was mixed by hand, the mixture being composed of one part Nazareth Portland cement, three parts sand and stone dust and four parts of ¾-in. stone, which proportions produced a dense, compact concrete. The amount of pipe covered by these figures contained 405.55 tons of stone and dust, at $1.50; 137.5 tons of sand, at $1.20 per ton, and 454 barrels of cement, at $1.39 per barrel, making a total of $1,404.38 for materials, or a total of $2,437.38 for both labor and material. The amount of pipe made at this total cost included 317.3 cu. yd. of concrete, or $7.67 per cubic yard.

The sections of pipe as they were laid were each supported by a goose-neck having a broad surface bearing on the inside of the pipe, and with a ring at the outer end hooked to a chainfall from a duplex block suspended on a wooden tripod. When each section was laid accurately to line and to grade the succeeding section could be fitted perfectly, but any deviation caused an opening which had to be caulked later with hemp. With a ditch at grade a gang of six men could slip into place the tie bands between the sections and grout 100 ft. of either 30 or 36-in. pipe in a day of 8 hr. The cuts in this work, however, were shallow, and Mr. Taylor says the depth makes a material difference in the time of lowering. The spigot end of the sections was laid down-stream, with one of the reinforcing bars at the top. After a section was laid two galvanized-iron shields, 6 or 8 in. wide, were slipped around the joint between each pair of sections, with half the width of this shield projecting beyond the sectional area. The next length of pipe is then fitted and locked in place by a tie band. The shield is then drawn up snugly around the pipe and backed up to the springing line with dirt to hold it in place. The joint is completely filled with Portland cement mortar and the shield left in place until the shield has set. A bag of cement on the 30 and 36-in. sizes of pipe, when mixed with three parts of sand made sufficient mortar for four joints.

One of the rejected pipes, culled on account of a broken bell, was tested for strength. The pipe was laid on its side on the surface of the ground, with two pieces of 6-in. blocking to hold it from rolling. A saddle was built to fit on the pipe, so as much as possible of the weight used in testing came on the crown of the arch. When the pipe was loaded no cracks developed until 10,000 lb. of pig lead had been placed on the saddle. Two longitudinal cracks then opened on the inside and extended the entire length of the section, one at the top and one at the bottom, but no indication of failure was visible from the outside. A lack of facilities for loading prevented the section to be tested to failure.



Section of Spillway of Dam.

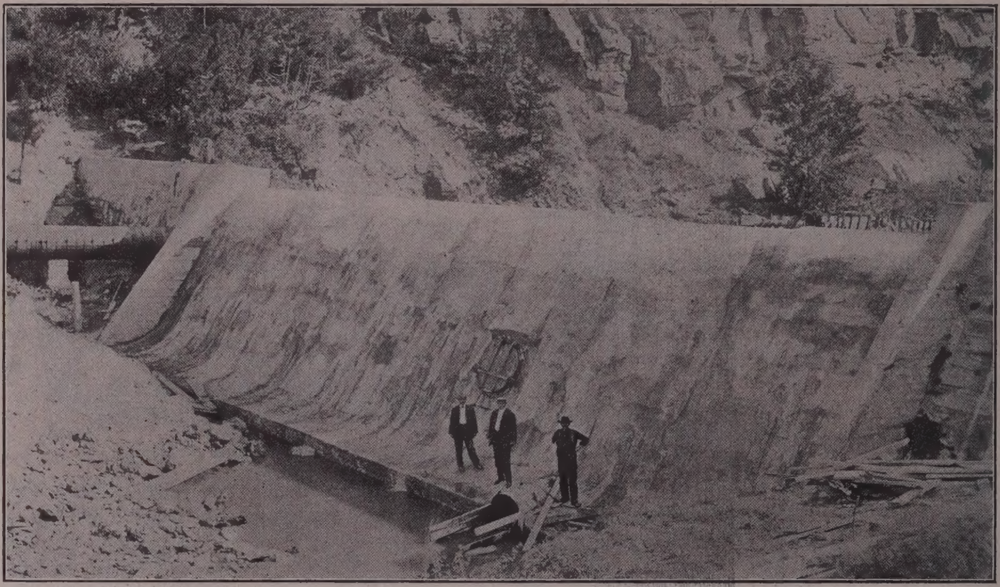
An Aerial Ferry Bridge of 250-ft. span and 75-ft. headroom, consisting of a suspension bridge carrying a track on which runs a carriage supporting a car just above high water level, has been built across the River Mersey at Warrington, England, connecting the two plants of Messrs. Joseph Crossfield & Sons. A ferry was thought impracticable because of the tidal rise and rapidity of the tidal current, and no room could be found for tunnel approaches, while a bridge of the usual type would have required still longer approaches to secure the necessary headroom. The bridge is built on the suspension type and has two 7-in. main cables carried on steel towers. Single vertical suspenders, 1¼ in. in diameter, on 10-ft. centers, on each cable carry the riveted stiffening trusses and the runway channels which serve as tracks for the carriage of the suspended car. The latter has a capacity of 2½ tons.

A Small Concrete Dam

By Samuel H. Lea, State Engineer of South Dakota.

The writer was called upon last season to furnish a design for a concrete dam which, while not possessing any remarkable features, furnishes an interesting example of concrete construction quickly and economically done. The dam was built by the Water, Light & Power Co., of Hot Springs, South Dakota, across Fall River, about 3½ miles below the town of Hot Springs.

Fall River is a stream which is fed largely by hot springs along its upper portion, and the water in its channel never freezes, remaining warm even during the coldest winter weather. This is a valuable feature in the operation of a water-power plant, especially in a cold climate, since there is never any trouble caused by the formation of ice. Another valuable feature connected with this stream is that its flow is fairly uniform because of the even flow of the springs that feed it. The watershed of the stream above the dam site is small in area and there are consequently few floods in its valley of large volume, or of long duration. These natural features were taken into consideration in designing the form of cross-section for the dam, as will appear later on.



A View of the Completed Dam.

The fall of the stream valley is rapid; and at a point about half a mile below the dam there is a series of rapids and falls of considerable height, offering a good opportunity for water power development. The company has operated a power house at the falls for several years, where power is generated under a head of 112 ft. The water was conveyed through flume, wood-stave pipe line and canal from an old crib dam, located about 600 ft. up stream from the new dam. The pondage caused by the old dam was insufficient to furnish the required flow of water, especially during the time of the peak load when the small reservoir would be rapidly depleted.

In order to secure a larger reservoir and a great increase in storage capacity the company decided to construct a new dam, located lower down the valley, but with the same crest elevation as the old dam. This would furnish the same hydraulic head as before and would not require any change in the grade of the pipe line, flume or canal.

It was desired to obtain as long a spillway as practicable and at the same time to protect the two ends of the dam from overflow. At the western end is the inlet of the pipe line; and at the eastern end the ground is low and subject to erosion if not protected. The spillway occupies the central portion of the dam for the greater portion of its entire length, and this is flanked at either end by buttresses which rise 2 ft. above the crest of the spillway. The form of cross-section adopted for the spillway or overflow is shown in an accompanying illustration. This appears to be a rather daring design, approaching closely the theoretical form of cross-section for a dam. As stated previously, however, there is never any floating ice in the stream because of the high temperature of the water; and but little danger from floods because of the small drainage area above the dam. Taking these facts into consideration it was decided not to incur useless expense by building an unduly heavy section.

It was important that the flow of water from the old dam to the power house should not be interrupted during the construction of the new dam. The wood-stave pipe line conveying the water across the dam site was therefore not disturbed, but was all allowed to remain in place while the concrete for the new dam was deposited around it.

The bed of the stream consists of solid rock of hard sandstone formation, affording an excellent foundation. At the west end of the dam good anchorage was furnished by a rock bluff; but the eastern end connected with a bank of ordinary earth. At this end a water-tight connection was made by extending a concrete wing some distance into the earth bank and by puddling around the end and face with clay, well tamped.

As soon as the design of the dam was completed work was begun erecting the forms for concreting. A track was built, parallel to the longitudinal axis of the dam, along the top of the forming at a sufficient height to clear the top of the concrete. The latter was mixed in a double-cone mixer located at the eastern end of the dam. This mixer discharged into cars which were run out on the track by hand and dumped at the required place. The concrete was mixed wet in the following proportions: Portland cement, 1; sand, 2½; crushed stone, 5. Displacers were used in the form of large stones, varying in size from that of a man's head to two-man stones. These were freely used throughout the entire mass, care being taken not to allow adjacent stones to come closer than 6 in. apart. It was intended to have about 40 per cent. of the structure consist of displacers, and this proportion was maintained as nearly as practicable. The dam was anchored to the bedrock foundation by means of anchor bolts, as shown in the cross-sectional plan. These bolts were of iron, about 1½ in. square and 3 ft. long. They were spaced about 6 ft. apart over the area of the base, and were embedded about half their length in the foundation and were slightly staggered upstream.

The bulk of the stream flow was taken care of by the pipe line from the old dam, but there was considerable underflow along the surface of the bed rock. This flow was carried through a section of 48-in. wood-stave pipe, laid on top of the foundation rock. This pipe was left in place after the completion of the dam. A valve was placed at the upper end and the opening will be used for a blow-off when necessary. The completed dam is shown in an accompanying illustration.

The flume connecting the pipe line with the old dam can be seen just over the crest of the new dam near the east end. This flume has since been removed. The blow-off is seen on the right hand or eastern end. The flap-valve seen at the center of the spillway is intended for an emergency valve. It is not a part of the dam design, but was made by the foreman after the fashion of similar valves in Holland.

Cost of Work.—In a piece of work of this character it is always interesting to know the cost of construction and in this instance the writer was careful to ascertain, as nearly as practicable, the several items of cost. The company invited bids from contractors for doing the work, and the lowest bid received was $7.50 per cubic yard for the structure complete. The dam contains 1,100 cu. yd. of masonry, and, at the above rate, this would make the contract price $8,250. This price was considered too high and the company decided to have the work done by direct labor under the supervision of their general foreman. In the accompanying Table 1 are items of cost as furnished by the company from their construction records:

TABLE I.

Concrete materials, Cement f.o.b. Hot Springs, per barrel	$3.27
Hauling to dam site, per barrel	0.23
Cost of cement at dam site, per barrel	$3.50
Sand and concrete, delivered, per cu. yd	1.50
Crushed stone, delivered, per cu. yd	2.25
Cost of concrete in place per cubic yard:	
Concrete	
1.2 bbls. cement at $3.50	$4.20
0.46 cu. yd. sand at $1.50	0.69
0.90 cu. yd. crushed stone at $2.25	2.03
Mixing concrete and placing forms	0.76
Total cost of concrete in place per cu. yd	$7.68
Large Stone for Displacers.	
Team for snaking and hauling, per day	$5.00
3 men quarrying and loading, per day	7.50
2 men unloading and placing, per day	5.00
Total	$17.50

The stone was obtained on the hillside in the vicinity of the work and the only expense incurred in its use was that of labor and hauling. There was an ample supply of small boulders and detached pieces of suitable size available for use without blasting. These were readily pried out of the ground by hand or snaked out by team and, being conveniently located with respect to the work, were placed in the dam at a comparatively small cost. The total cost of this stone in place in the dam was $314.50. The amount of stone used for displacers was 425 cu. yd., or about 40 per cent. of the total yardage of the dam.

The cost per cubic yard of displacers when in place in the dam was as follows: Quarrying, loading and hauling, $0.43; unloading and placing, $0.32; total, $0.75.

The total volume of material in the dam is 1,100 cu. yd. The cost of the dam complete, including concrete and the large stones used for displacers as separate items, is as follows: Concrete, 675 cu. yd., at $7.68, $5,184; large stone for displacers, 425 cu. yd., at $0.75, $314.50; total, $5,498.50.

The dam has been in use about a year and is apparently in perfect condition. Some apprehension was felt by officers of the company, at the time of its construction, as to the water tightness of the structure, owing to the large percentage of displacers used. A recent inspection, however, disclosed no leakage or seepage of any kind through or around the dam.

The dam was constructed by the Water, Light & Power Co., of Hot Springs, South Dakota, under the direction of Mr. J. F. Parks, superintendent. John Mueller, general foreman of the company, was in local charge of the work.

Comparative Tests of Alcohol and Gasoline in Engines.

The Technologic Branch of the U. S. Geological Survey, under the direction of Mr. J. A. Holmes, has recently completed an elaborate series of tests on the relative value of gasoline and alcohol as producers of power. The tests, over two thousand in number, probably represent the most complete and exact investigation of the kind that has been made either in this country or abroad, and includes much original research work. Prof. R. H. Fernald, engineer in charge of the gas producer section and professor of mechanical engineering in the Case School of Applied Science, was in general charge of the tests. Mr. R. M. Strong, formerly connected with the engineering department of Columbia University, had personal supervision of the work. He was assisted by a corps of specially trained men. These tests were conducted at the Fuel Testing Plant of the Geological Survey at Norfolk, Va., and shows the following results in regard to the comparative fuel consumption of 73 deg. specific gravity gasoline and commercial completely denatured alcohol, per unit of power.

Correspondingly well designed alcohol and gasoline engines when running under the most advantageous conditions for each, will consume equal volumes of the fuel for which they are designed, according to these tests. This statement is based on the results of many tests made under the most favorable practical conditions that could be obtained for the size and type of engines and fuel used. An average of the minimum fuel consumption values thus obtained, gives a like figure of 0.8 pint per hour per brake-horse-power for gasoline and alcohol. Considering that the heat value of a gallon of the denatured alcohol is only a little over six-tenths that of a gallon of the gasoline, this result of equal fuel consumption by volume for gasoline and alcohol engines probably represents the best comparative value that can be obtained for alcohol at the present time, as is also indicated by continental practice. Though the possibility of obtaining this condition in practice here has been thoroughly demonstrated at the Government Fuel-Testing Plant, it yet remains with the engine manufacturers to make the "equal fuel consumption by value" a commerical basis of comparison.

The gasoline engines that were used in these tests are representative of the standard American stationary engine types, rating at 10 to 15 h.p., at speeds of 250 to 300 r.p.m., while the alcohol engines were of similar construction and identical in size with the gasoline engines.

The air was not preheated for the above tests on alcohol and gasoline, and the engines were equipped with the ordinary types of constant-level suction-lift and constant-level pressure-spray carburetters. Many special tests with air preheated to various temperatures up to 250 deg. Fahr., and tests with special carburetters were made, but no beneficial effects traceable to better carburation were found when the engines were handled under the special test conditions, including constant speed and best load.

The commercial completely denatured alcohol referred to is 100 parts ethyl alcohol plus 10 parts methyl alcohol plus ½ of one part benzol, and corresponds very closely to 94 per cent. by volume or 91 per cent. by weight ethyl alcohol (grain alcohol).

No detrimental effects on the cylinder walls and valves of the engines were found from the use of the alcohol.

The lowest consumption values were obtained with the highest compression that it was found practical to use; which compression for the denatured alcohol ranged from 150 to 180 lb. per square inch above atmosphere.

Eighty per cent. alcohol (alcohol and water) for use in engines of the present types would have to sell for at least 15 per cent. less per gallon than the denatured alcohol in order to compete with it. The minimum consumption values in gallons per hour per brake-horse-power for 80 per cent. alcohol is approximately 17.5 per cent. greater than for the denatured alcohol used or for gasoline. A series of tests made with alcohol of various percentages by volume ranging from 94 to 50 per cent. showed that the minimum consumption values in gallons per hour per brake-horse-power increased a little more rapidly than the alcohol decreased in percentage of pure alcohol. That is, the thermal efficiency decreased with the decrease in percentage of pure alcohol. This decrease in thermal efficiency or increase in consumption referred to pure alcohol is, however, comparatively slight from 100 per cent. alcohol down to about 80 per cent. alcohol. Within these limits it may be neglected in making the calculations necessary to compare the minimum consumption values for tests with different percentages of alcohol.

The nearer the alcohol is to pure, the greater the maximum horse power of the engine. The percentage reduction in maximum horse power for 80 per cent. alcohol as compared with that for denatured alcohol used was less than 1 per cent., but the starting and regulating difficulties are appreciably increased.

With suitable compression, mixtures of gasoline and alcohol vapors (double carburetters) gave thermal efficiencies ranging between that for gasoline (maximum 22.2 per cent) and that for alcohol (maximum 34.6 per cent) but in no case were they higher than that for alcohol. The above thermal efficiencies are calculated from the brake-horse-power and the low calorific value of the fuel, which for the gasoline was 19,100 B.t.u. per pound and for the denatured alcohol was 10,500 B.t.u.

As has been previously published, alcohol can be used with more or less satisfaction in stationary and marine gasoline engines and these gasoline engines will use from one and one-half to twice as much alcohol as gasoline when operating under the same conditions. The possibilities, however, of altering the ordinary gasoline engine as required to obtain the best economies with alcohol are very limited; for the amount that the compression can be raised without entirely redesigning the cylinder head and valve arrangement is ordinarily not sufficient, nor are the gasoline engines usually built heavy enough to stand the maximum explosive pressures, which often reach 600 and 700 lb. per square inch. With the increase in weight for the same sized engine designed to use alcohol instead of gasoline, comes an increase in maximum horse power of a little over 35 per cent., so that its weight per horse power need not be greater than that of the gasoline engine and probably will be less.

The work was taken up to investigate the characteristic action of fuels used in internal combustion engines with a detailed study of the action of each fuel (gasoline and alcohol) as governed by the many variable conditions of engine manipulation, design and equipment. These variables were isolated, so far as possible; their separate and combined effects were determined; worked out under practical operating conditions, and lead up to the conditions required for minimum fuel consumption. The results show the saving that can be obtained over conditions for maximum consumption, and also establish a definite basis of comparison under conditions most favorable to each fuel. This latter is a point of much commercial interest and a study of the comparative action of gasoline and alcohol may be of great service in solving some of the general internal combustion engine problems where other than liquid fuels are used.

A large number of fundamental tests were necessary in order to clearly define conditions and interpret results. In a way they follow the work conducted by the Department of Agriculture, supplementing to a certain extent, but not duplicating Bulletin 191 which gives much valuable data.

Many of the tests of internal combustion engines have been made, but most of them especially in this country were by private concerns, for a specified purpose, and the results are not generally available. Furthermore, as is generally recognized by those familiar with gas and especially gasoline engine operation, the conditions influencing engine performance are so numerous and varied as to make the value of off-hand comparison very limited and oftentimes misleading, exact comparisons only being possible under identical conditions or with reference to the actual known differences in all conditions that influence the results. This investigation was made with a view to supplying the continually increasing demand for more complete and exact information, concerning the operation and design of gasoline and alcohol engines and to assist the government and others interested in the larger and more general internal combustion engine problems.

Book Notes.

A book by Mr. Wm. M. Venable on "Methods and Devices for Bacterial Treatment of Sewage" has recently appeared which is rather difficult to classify, for a part of it consists of an outline of many American patents relating to sewege disposal, a part is an explanation of the general features of disposal systems of the bacterial class, and a part is a detailed account of the author's experience in rebuilding three small disposal plants in the Middle West. The introductory chapter briefly explains what is meant by the bacterial treatment of sewage and the second chapter gives a list of books on the subject and references to similar articles in technical journals. The aerobic treatment of crude sewage, the mechanical removal of sludge, the anaerobic treatment of sewage, intermittent contact systems, automatic discharging devices and percolating filters are given a chapter each, after which there is a summary of engineering principles regarding the design of sewage purification works. The tenth chapter is the most instructive in the book, as it gives the author's experience in reconstructing three small works built for the Quartermaster's Department, U. S. A., by a contractor who undertook to design and build works to accomplish certain results. The story is an excellent warning to those who believe that a specialist need not be consulted in connection with sewage disposal undertakings. In the final chapter the author gives some designs of works to meet typical conditions. (New York, John Wiley & Sons, $3.00).

The prompt publication of "The Engineering Index Annual" for 1907 will be appreciated by all who have learned to rely upon this well-edited work for ready reference to the leading articles in the world's engineering periodicals. It is a bit of a shock to those familiar with this undertaking since it was begun under the direction of the Association of Engineering Societies to notice that this volume completes the twenty-fourth consecutive year of the work, for it shows how old some of us are growing, even if we resent the application of that term to us. The admirable classification of the notes adopted by "The Engineering Magazine" is preserved; most engineers are already familiar with it and those who are not can understand it after a few minutes examination of the book. In some respects a more complete alphabetical classification might be desirable, possibly, but the publication of these volumes is a most expensive task and if the expense is lightened materially by publishing the notes under the same classification followed in the "Magazine" it was a good business move for the publisher to adopt that plan, particularly as it enables him to issue the annual volume so promptly. The book will prove invaluable to anyone desiring to refer to the more important articles in the technical press of last year. (New York, The Engineering Magazine, $2.00).

Letters to the Editor.

Operating Results With the Pittsburgh Filters.

Sir: We have had a number of inquiries as to the results being obtained from the Pittsburgh filters, and thinking by publication in the engineering papers these results would be made known in a way that would be broadcast, and at the same time give authenticity, I feel that you will be interested in receiving a few facts and publishing them.

In the accompanying table is given the date when each filter was started. It will be noticed that there are 23 filters running to-day; some having been running since the middle of December. Each one has been running at a low rate, the maximum being 2½ million gallons recently used for two of the filters, and one of these was thrown out of service for cleaning on April 8. The average bacteria for the week ending April 25 are shown in the table and it is interesting to note that while investigations for the determination of the number of bacilli coli communis per cubic centimeter have been conducted in the effluents from the filters, it has been found only 16 times, and then never above two at a time, since the first of March.

Date of Starting Pittsburgh Filters and Average Number of Bacteria per Cubic Centimeter During Week Ending April 25.

Filter No.	Date started	Bacteria per cc.	Filter No.	Date started	Bacteria per cc.
1	Jan. 2	37	15	March 8	70
2	Jan. 6	200	16	March 7	33
3	Jan. 11	199	17	April 1	133
4	Jan. 10	24	19	March 8	49
5	Jan. 17	61	20	April 17	—
6	Jan. 17	71	21	March 9	42
9	Dec. 18	68	22	March 10	87
10	Jan. 3	30	23	March 1	45
11	Dec. 27	42	25	April 1	170
12*	Dec. 28	—	26	April 1	128
13	March 6	65	28	April 1	53
14	March 4	70	30	April 1	245

*Now being cleaned.

Coli in the river water is always present in numbers from five to thirty, and in the settled and applied water, nearly always present up to three or six.

The operation of the filters is under the care of Mr. Chester F. Drake, assistant superintendent of filtration, who was formerly connected with the Bureau of Filtration of Philadelphia, and recently in charge of private water-works near Pittsburgh.

Yours truly,

M. Knowles, Chief Engineer.

Pittsburgh, May 2.

Garbage Disposal.

Sir: Your article on the Seattle refuse destructor, published on May 2, is interesting as showing the spreading of the idea that the destruction of municipal wastes is a problem requiring sound engineering judgment. The trouble with refuse disposal undertakings in this country has generally been the belief of municipal authorities that all they had to do was to buy a patented form of destructor, turn it over to the care of men who knew nothing whatever about handling furnaces for burning up the material that is difficult to incinerate, and leave the collection of this material from the houses of the city to slovenly men who soon neglected to keep their cars any cleaner than themselves. It is an axiom of sanitary engineering that everything connected with the handling of offensive materials must be kept as clean as possible, for otherwise offense will arise not only from the materials to be handled, but still more from the apparatus used in handling them. Refuse disposal is not solely a matter of a garbage incinerator; it begins with the collection of the refuse and does not end until the clinker from the refuse furnaces is utilized or thrown away. It is gratifying to see that Mr. Thomson has determined to do just as good work on the Pacific Coast as Mr. Fatherston has undertaken on Staten Island.

Very truly yours,

G.

Dustless Roads.

Sir: The description of the experiments with different dust preventives on a road at Wayland, Mass., in your issue of May 2, coupled with the information you recently printed concerning some experiments in Great Britain, confirms a belief that I have long held concerning the necessity of somewhat revising our methods of constructing broken stone and gravel roads subject to heavy travel. It is an excellent thing to be conservative and to endeavor to utilize standard forms of construction for new conditions, but a time comes in the development of every art when standards must be abandoned in favor of more economical construction. It seems to me that recent experience indicates that this condition has at last arisen in macadamized road building. I do not believe that a road constructed in the usual manner with water sprinkling is tenacious enough to withstand the suction of large pneumatic tires passing over them at high speed. So long as the loads imposed on the road surfaces were simply vertical and were due solely to the weight of the vehicles, the binding effect produced by the usual methods of construction was unquestionably adequate, providing the work was properly done and the materials for the road were selected with due regard to the character of the traffic coming upon the surface. The action of pneumatic tires is entirely different, however, from that of hard tires. These pneumatic tires press down upon the surface of the road and are then lifted up so quickly from such a large area that a suction is produced on the surface of the road which is the cause of its disintegration. It is therefore necessary to provide against this suction, and it seems to me that the only way to do this is to bind the road with some material which will have sufficient tenacity to resist this new form of destructive action. It does not seem logical that a sprinkling of some preparation of tar or asphalt or oil over the surface will be sufficiently binding and I believe that engineers will eventually come to the conclusion that the upper surface portion of the road, at least, must be bound with some preparation of a sticky nature. Just what this substance will be or what the method of using it will be, it is impracticable to state at this time, but the evidence of such experiments as have recently been described in your journal is conclusive that the cost of such work will not be excessive, provided pains are taken when constructing the road to conduct the work as economically as possible. I agree fully with the statements made in a recent editorial in your journal that the expense of tar macadam is too great for country road construction, but it should be possible to work out some kind of apparatus by which a tarry binding material can be sprinkled over the upper part of the road and the final coating then applied and rolled into the substance so that the binding and rolling of the road may be made a single operation.

Very truly yours,

C. E.